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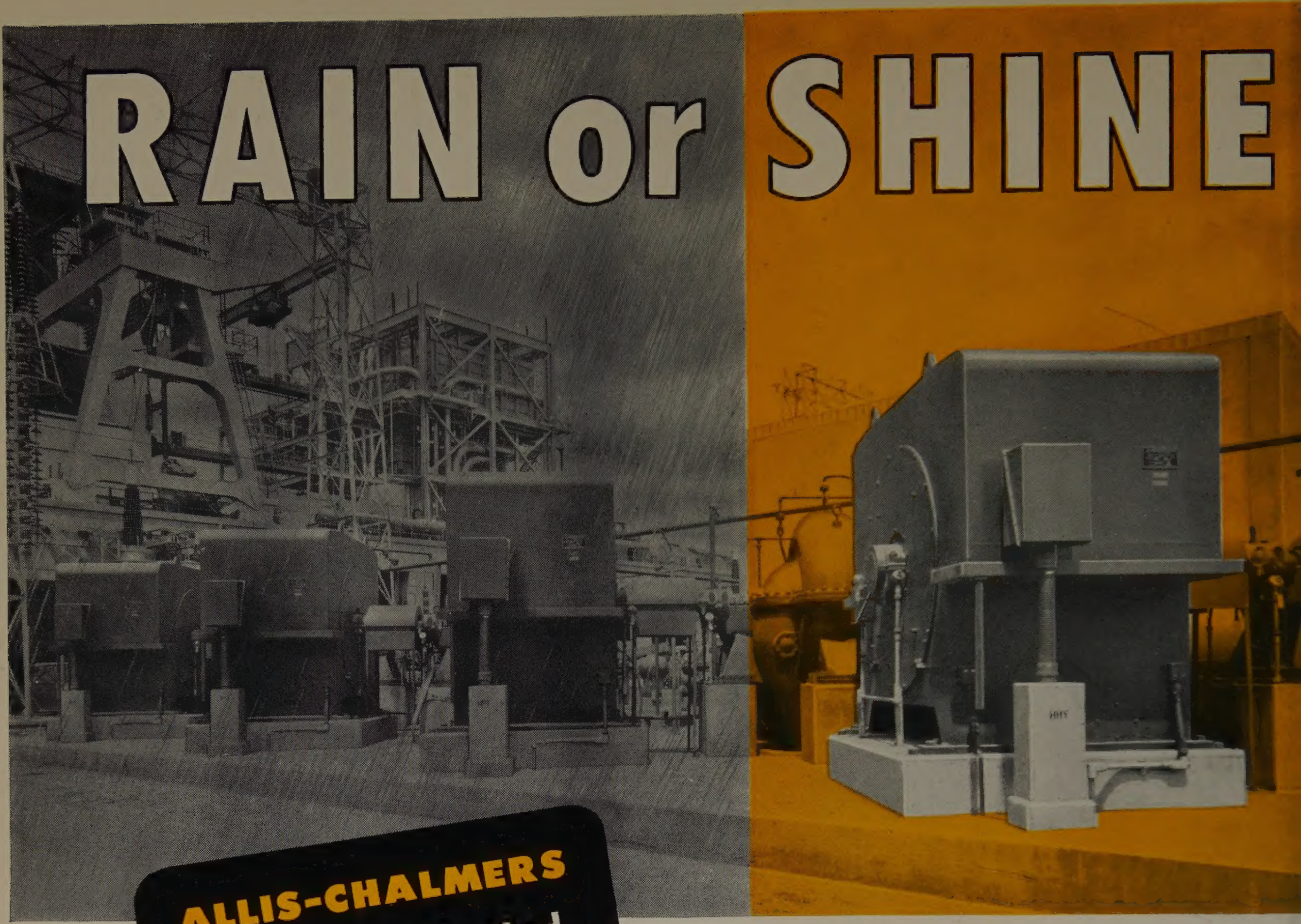
ELECTRICAL ENGINEERING

DECEMBER 1953

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS



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The Cover: Experimental 3-dimensional radar, a part of the Volscan air traffic control system developed by B. F. Greene, Air Force Cambridge Research Center, which also includes electronic tracking and computing equipment. The antenna on the left is the scanning or search antenna; the central and right antennas are for height finding. With this complex, Volscan determines height, range, and azimuth. These data then are fed into the control system itself.

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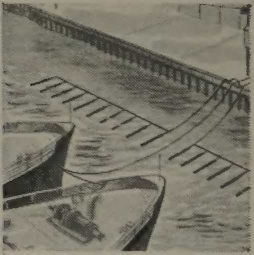

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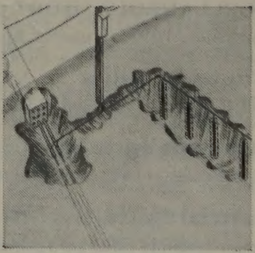

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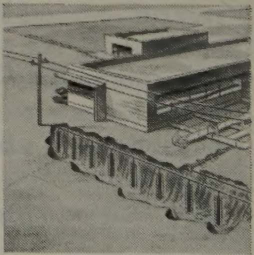

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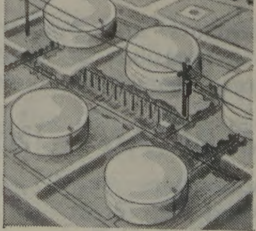

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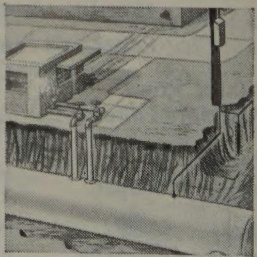

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HIGHLIGHTS........

Institute Meetings. With 92 sessions scheduled thus far, this year's Winter General Meeting in New York, N. Y., promises to be the biggest and best ever. As in the past, a number of interesting inspection trips and a complete social program are being planned also (*pages 1114–15*). Another coming meeting of special interest is the Computer Conference in Washington, D. C., of which the AIEE will be a joint sponsor. "Information Processing Systems" will be its theme (*pages 1126–7*). Recently held meetings reported in this issue include the Fall General Meeting in Kansas City, Mo., (*pages 1115–19*); the sixth annual Conference on Machine Tools in Cleveland, Ohio (*page 1126*); the Aircraft Technical Conference in Seattle, Wash., (*pages 1119–20*); and the Conference on Air-Moving Equipment in Fort Wayne, Ind. (*page 1123*).

AIEE Milestone. With the assumption in October of full Section status by the former New Hampshire Subsection of the Boston Section, the AIEE officially recognized the organization of its 100th Section. The Susquehanna Section recently became the 99th (*page 1125*).

Atomic Power in Ohio. Technically atomic power is here, but atomic power that can compete in the market place is another matter. This is particularly true of an area like Ohio because of its favorable location with respect to ample and economical supplies of coal. Because of the almost bewildering number of possibilities in power reactor design, it will be necessary to build and operate a number of reasonably full-scale reactor systems before the advantages and disadvantages of each type can be determined. This too will make possible engineering-economic evaluations which may lead to practical atomic power (*pages 1047–51*).

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Stereophonic Recording Equipment. In the search for more natural reproduction of recorded speech and music, engineers have been experimenting for nearly 20 years with auditory perspective. One of the latest developments is described (*pages 1053–6*).

Role of Thermal Overload Relays and Molded-Case Breakers in Appliance Protection. Appliance motors must be protected against overheating due to running overloads or stalled-rotor condition to avoid fire hazards. Thermal overload relays of the bimetal or solder-film type are available which provide satisfactory motor protection. Molded-case air circuit breakers of the domestic or industrial type provide adequate protection for the motor branch circuits against damage due to short circuits (*pages 1056–60*).

Forced-Air Cooling of Power Transformers. The various methods of forced-air cooling of power transformers which have been used are reviewed. A complete description of modern methods is given which includes equipment, operation, and control (*pages 1071–5*).

Noise and Crosstalk Control on N1 Carrier Systems. The sources of noise and crosstalk on *N1* cable-carrier circuits are outlined, and the design features and engineering measures used to limit the interference are discussed. A high grade of transmission performance has been achieved without the elaborate and costly treatment of cable plant necessary with earlier types of cable-carrier systems (*pages 1075–80*).

Transformer Design for Resistance Welding Machines. The basis of transformer ratings and factors affecting the design are discussed together with factors which should be of primary interest to power companies and users of welding equipment (*pages 1088–93*).

Mine-Trailing Cables. The five chief types of construction are discussed as well as the four major causes of damage and maintenance suggestions (*pages 1061–5*).

A Limiter Analyzed as a Variable-Gain Device. A method of determining the output spectrum of the amplitude limiter is described which also can be used to ascertain the side-band spectrum of the angle-modulation component of a signal. Two examples are included: a 2-tone input signal, and the common limiter diversity system. The latter is shown to degrade appreciably the signal-to-noise ratio when the diversity input signals are approximately equal in amplitude (*pages 1106–09*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

System Grounding in Industrial Plants. Many of the failures on ungrounded electric systems can be traced to overvoltages. System grounding will eliminate these failures and permit more economical operation of the system (*pages 1098–1103*).

Economic Factors of Small-Capacity Hydroelectric Stations. Simplified automatic hydroelectric plant design offers new economic considerations for electric generation. Operating experience has indicated that induction generator hydroelectric plants are reliable and have many advantages (*pages 1083–8*).

Frequency and Fluorescent Lamps. The preferable frequency for operating fluorescent lamps should be chosen after considering the lamp characteristics, acoustics, equipment weight, and other factors. Why the optimum frequency for this type of lamp lies between 3,000 and 10,000 cycles is shown (*pages 1066–70*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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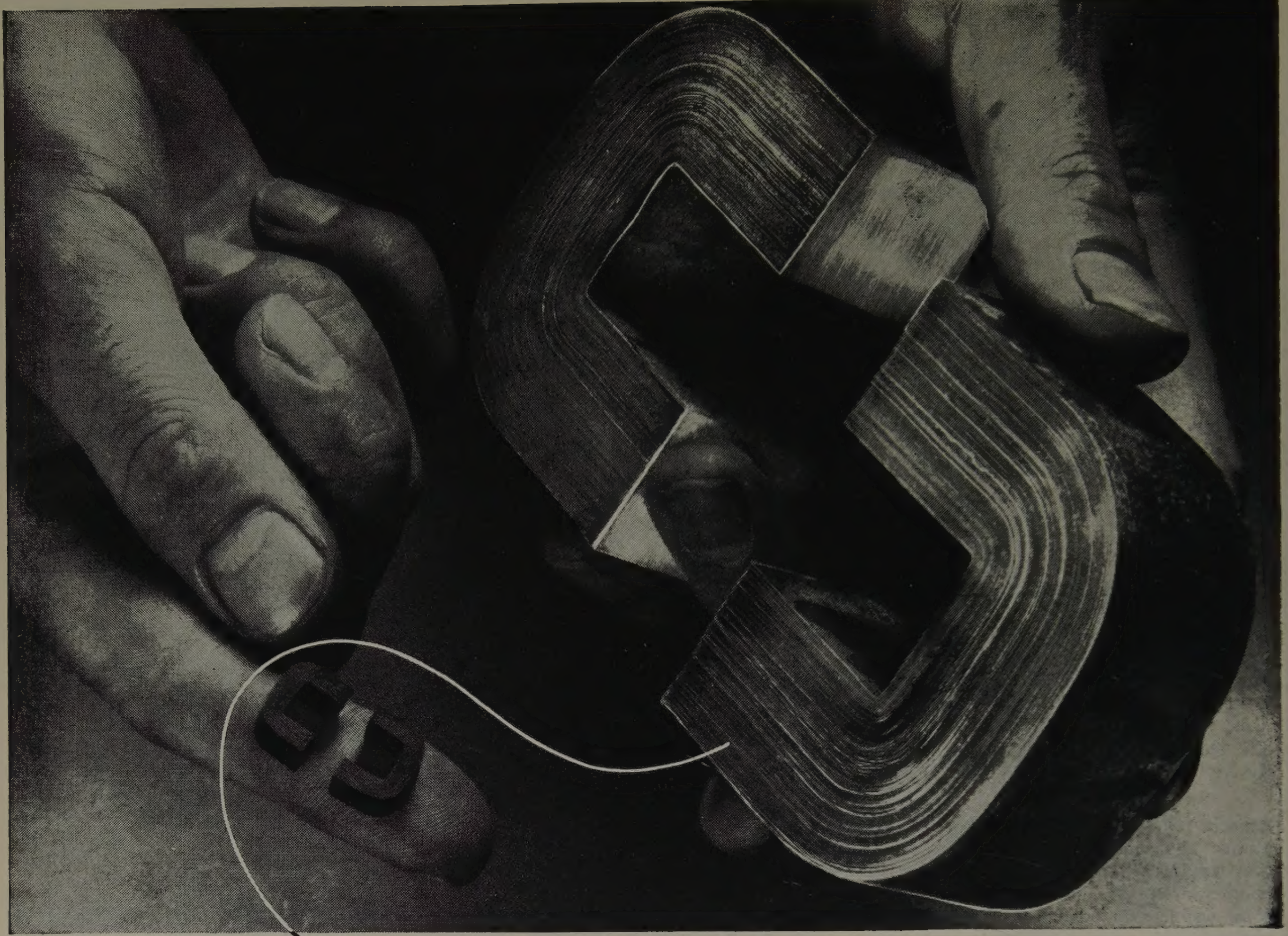

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Atomic Power in Ohio

PHILIP SPORN
FELLOW AIEE

SINCE August 6, 1945, when the atom first burst on the world's consciousness with the bomb which rocked Hiroshima, the State of Ohio has contributed enormously to the development of the atom. Up to now, most of that development has had for its object a strengthening of our defenses. That continues to be of paramount importance. Yet we also continue to hope that the atom will justify the sweat and toil that have been invested in it by leading to useful and significant peacetime applications for the benefit of the people of this state and nation, and the world. Before getting into a discussion of the prospects for realizing that hope, you may be interested in a brief review of what work Ohio has done on the atom.

OHIO'S ROLE IN THE ATOMIC PROGRAM

ALL OF YOU have heard of the Portsmouth Area Project now being erected by the Atomic Energy Commission in Pike County; you have heard of the 1,000,000-kw Kyger Creek steam electric plant being built in Gallia County to supply a part of the power requirements at Portsmouth. It is not so well known that there are a good many other operations in the atomic program that also are located in Ohio. There is, for example, the Mound Laboratory at Miamisburg in Montgomery County, where highly classified developmental work having to do with radioactive processes is going on. There is the Feed Materials Production Center at Fernald, west of Cincinnati, where the raw materials needed in the production of more concentrated fissionable material are processed. There is also the project at the Evendale Plant of the General Electric Company at Lockland, where work on design and development of a reactor for aircraft propulsion by nuclear power has been going on with increasing momentum.

Many of Ohio's leading industrial and engineering organizations have participated over the past half-dozen years in atom development. I mentioned the General Electric Company. I might mention, too, the Babcock and Wilcox Company, The Austin Company, and the H. K. Ferguson Company among others. Ohio's educational and research institutions also are playing a noteworthy part. Case Institute is carrying on classified work on a number of problems. That institute, Ohio State University, and the University of Cincinnati are among the group of midwestern universities which, with the University of Chicago, are acting as the contractor for the Atomic Energy Commission in the operation of the Argonne National Laboratory, in Cook County, Ill.

The electric power companies of Ohio for years have contributed to the supply of power to the Atomic Energy Commission. By co-ordinating their operations they have been able to supply large quantities of electric energy to installations of the Atomic Energy Commission where fissionable material was produced before permanent power facilities were completed. See Figure 1.

However, essential as this power supply has been, it is overshadowed by the obligation that the 15 power companies in the Ohio Valley area—seven of them companies serving the State of Ohio—undertook on October 15, 1952, to furnish the entire requirements of the Atomic Energy Commission's Portsmouth Project. They have contracted to deliver 1,800,000 kw and 15 billion kilowatt-hours per year to this new diffusion plant of the Commission. This is the largest contract for power entered into by a single customer in the history of the electrical utility industry. It is almost two-thirds of all the power used in 1952 in this great state, with its population of over 8,000,000 and its vast complex of industrial activities. See Figure 2. It is in connection with this undertaking that the 1,000,000-kw Kyger Creek power plant is being built in Gallia County. That plant will cost about $145,000,000; together with a companion plant, Clifty Creek, under construction in Jefferson County, Ind., and with the interconnecting 330,000-volt transmission facilities, this will bring the total expenditures for the Portsmouth project for power supply alone up to $400,000,000.

Ohio, you can see, is very heavily involved in the atomic program. Many of its communities, thousands of its citizens, and close to $2 billions of capital—a substantial

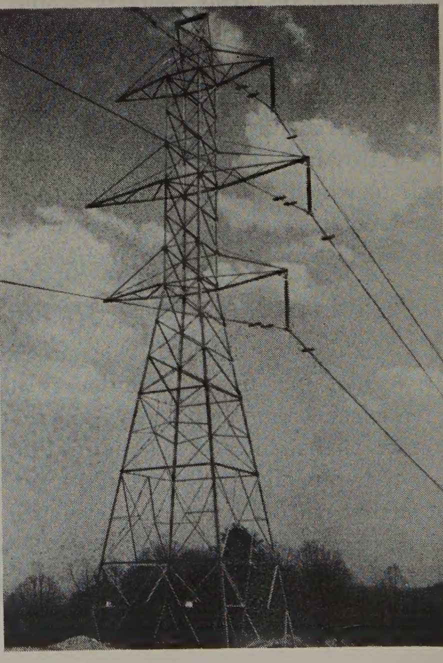

Figure 1. A view of the Sporn-Muskingum 330,000-volt transmission line now in actual operation at that voltage

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Full text of an address presented to the 60th annual meeting of the Ohio Chamber of Commerce, Columbus, Ohio, October 22, 1953.

Philip Sporn is president of the American Gas and Electric Company, New York, N. Y.

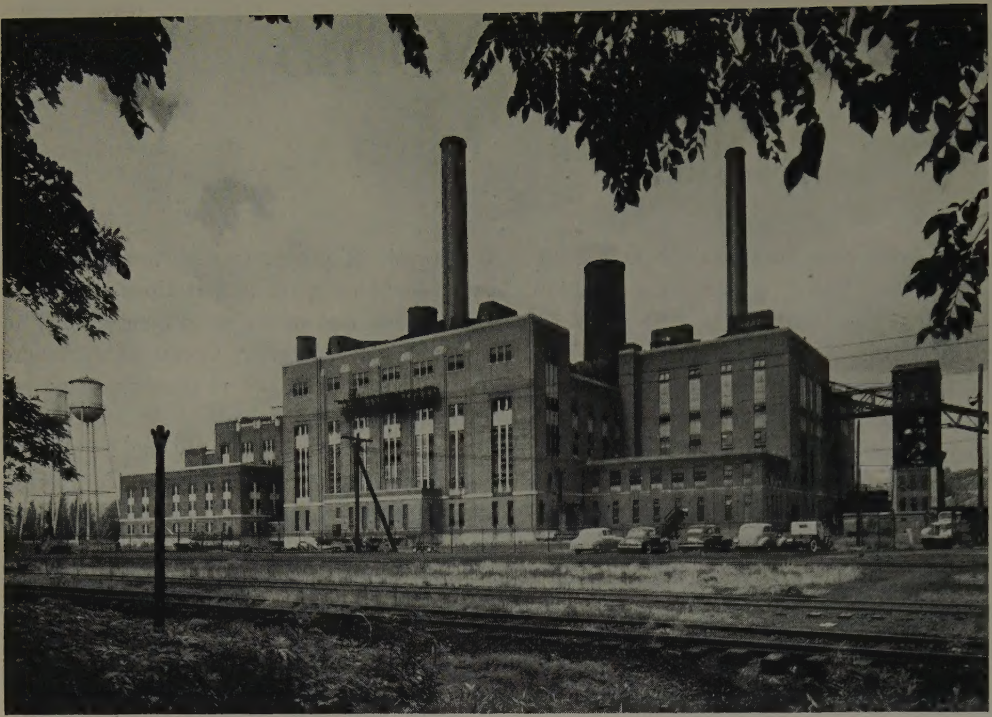

Figure 2. **The Ohio Power Company plant at Philo which generated $2\frac{1}{2}$ of the 23 billion kilowatt-hours of electric energy sold in Ohio during 1952**

part of it private capital—are dedicated to work on the atom in this state. As we get to know more about nuclear forces, and how to utilize their vast powers more effectively, Ohio certainly will continue to play a prominent part in that development and growth.

THE ROLE OF THE ATOM IN DEFENSE

To date the benefits of the atom have been largely defense benefits. Most of the effort has gone into producing fissionable materials like Uranium 235 or plutonium, and devices that exploit fissionable materials in weapons like the atomic bomb, or atomic shells, or the hydrogen bomb. While it is a pity that we have had to concentrate on arms, nobody would suggest today that it would be safe for us to slow the development and improvement of our atomic weapons. Atomic bombs may have an unpleasant sound, but we need them to help protect us against those who otherwise might be tempted to destroy us. The atomic bombs that we are producing, and to which Ohio is contributing so much, are perhaps the greatest single deterrent to our being overwhelmed by the world-wide communist menace.

PEACETIME PROSPECTS FOR NUCLEAR ENERGY

When we turn to the prospects for peacetime use, our major attention is directed immediately to nuclear energy as a new source of power. In pursuance of that interest it is natural and healthy to project our thoughts and our hopes into a future when this source of energy will have been so developed that it can take its place beside and perhaps even be more economical than the conventional forms, that is, those based on hydro or on fossil fuels—gas, oil, and coal.

Such a prospect is certain to excite the imagination of the people of this state with its constantly expanding economy—an economy that already uses almost two-thirds as much electric power as all of France, a nation with five times Ohio's population. Any development that can assure the availability of virtually unlimited amounts of energy and which would promise a more economical use of it is of vital interest to every inhabitant of the state.

Yet if we are to understand the significance of atomic power we must try to evaluate the prospects in practical terms. We must try to measure these prospects on some quantitative basis. If we are to answer the question of just how Ohio will benefit from atomic energy and its possible development in the near future, we must approach the question from the standpoint of first observing how the state has fared in the development of existing power resources and what its prospects are in this respect apart from atomic energy.

ELECTRIC POWER DEVELOPMENT

The United States has been in the forefront of electric power development for a long period. After all—thanks to the genius of a native of Ohio, Thomas Edison—electric power was born as an industry in this country nearly 75 years ago. One of the hazards of leadership is the tendency to grow complacent, to let younger, more vigorous competitors pull ahead while the original leader coasts on his earlier successes. We are fortunate in that no such complacency has developed in the electric power industry in this country. Evidence of our enterprise in this respect is apparent from many sources and nowhere better than from an examination of the world-wide expansion in electric power production that has taken place in the period 1940–1952. Canada's production expanded 106 per cent, France's 114 per cent, that of the United Kingdom 117 per cent, and that of Soviet Russia, with all its series of 5-year plans, 150 per cent. In the same interval the United States increased its power production 180 per cent. In the same interval the expansion in the electric energy production in the State of Ohio has proceeded at an even more rapid rate than the national average. Comparison of the figures of per capita energy production yields striking results. All the following data are expressed in round numbers. In 1952 the per capita sales in the United States as a whole were 2,200 kilowatt-hours, based upon sales of 340 billion kilowatt-hours, to a population of 157,000,000. If you examine the corresponding figures for six states, which are logically comparable with Ohio, you find Massachusetts with 1,500, New York 2,100, Illinois 2,200, Michigan and Indiana 2,300, Pennsylvania 2,600, and Ohio 2,900. Ohio thus stands out with a per capita energy use one-third above the national average; almost one-third above such great states as Illinois, Indiana, and Michigan, and significantly above all the other important sister states I have listed. See Figures 3 and 4.

The source of this energy used in Ohio is also significant. Small quantities are generated by hydro plants or from utilization of oil and gas, but these quantities are negligible. Ohio is in a singularly favorable location with relation to coal resources and nearly 99 per cent of its total requirements of electric energy are generated from coal. It is itself one of the great coal-producing states, having had an average output of close to 35,000,000 tons annually during the last 12 years. See Figure 5. With its borders on Pennsylvania, West Virginia, and Kentucky, Ohio is practically in the heart of the great Eastern Coal Province which at present produces about 85 per cent of all the bituminous coal mined in the United States. See Figure 6. As long as there are adequate coal reserves within the Eastern Coal Province, Ohio can look forward to an ever-expanding use of energy without going beyond the resources of its own mines and those of neighboring states. There is no agreement even among geologic experts as to what these reserves are. But it is well to note that disagreement is as to whether the reserves are adequate for the next 2,000 years or only for the next 300 years. If recent judgment has veered toward the lower figure, at least there is no disagreement that in this region reserves adequate for the next several hundred years are available and have been proved.

Other parts of the world, of course, are not so well situated with respect to conventional fuels. Indeed, even parts of this country—which in the main has been favored thus far with fairly well distributed, relatively plentiful sources of economical energy—will begin to face materially increasing costs in coming decades as the best deposits of fossil fuels are exhausted. In short, because of this state's situation with respect to coal, it is not likely to benefit from atomic power as soon as other parts of the world or other parts of this country which are not so ideally located with respect to conventional sources of energy.

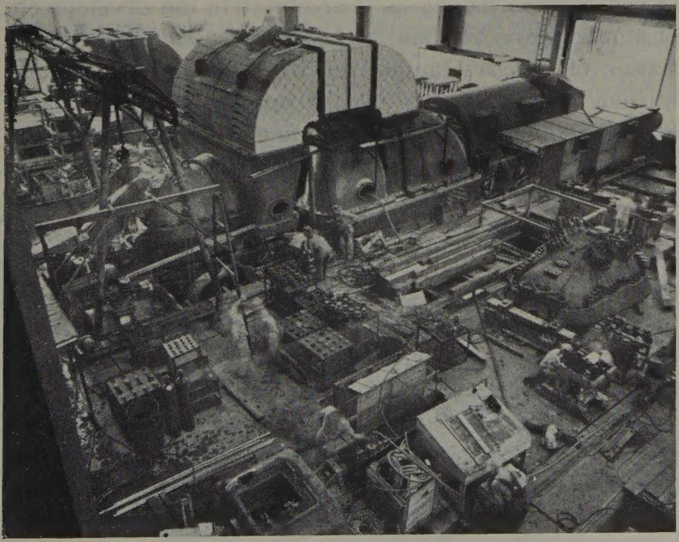

Figure 3. A 200,000-kw steam-electric generating unit under construction at The Ohio Power Company's new Muskingum River plant near Relief, Ohio, where a thermal efficiency of close to 38 per cent will be reached

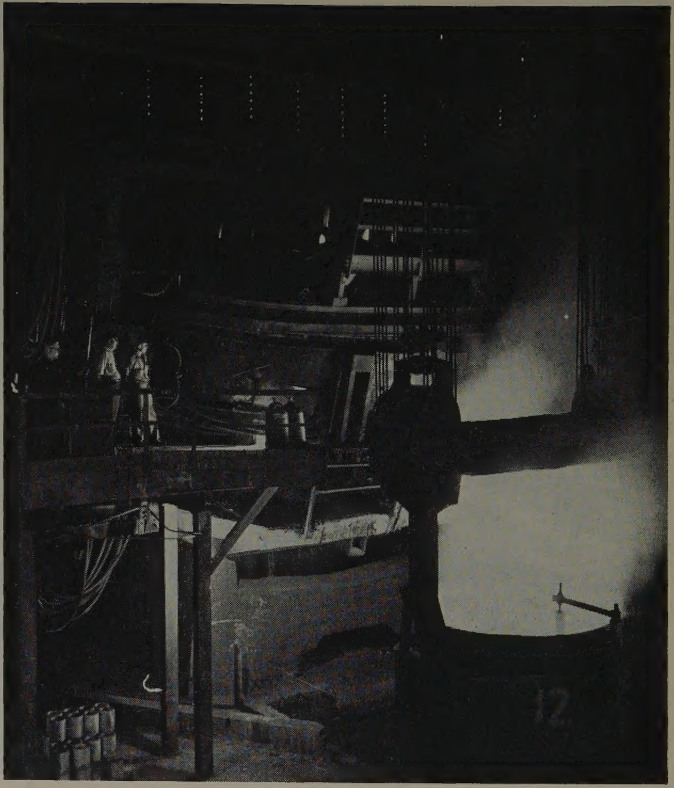

Figure 4. Tapping a heat of steel from The Timken Roller Bearing Company's 100-ton electric furnace at Canton, Ohio

STATUS OF ENERGY PRODUCTION BY ATOMIC FUEL

There has been a great deal of talk about atomic power in the last several months. One hardly can pick up a copy of the daily paper without finding an article or a report of a speech about it. The Joint Committee on Atomic Energy of the Congress held extensive hearings on the subject during the last summer and published a full account of these hearings. The object of the hearings was to determine what the facts were with regard to the possibilities of developing atomic power, what the various sections of our society thought about the problem, and, particularly, what private industry might be able to do to develop atomic power and bring about its peacetime use. These hearings make rather clear that commercial atomic power is not just around the corner and that very hard and very expensive time-consuming work remains to be done before commercial power can be a reality.

Now, it is important to avoid any confusion about the technical feasibility of atomic power. Atomic power in that sense is here: that is, we can produce power from the fissioning of atomic material, such as the material that will be produced in the Portsmouth Area Project when it starts operating in about a year or so. Technically this

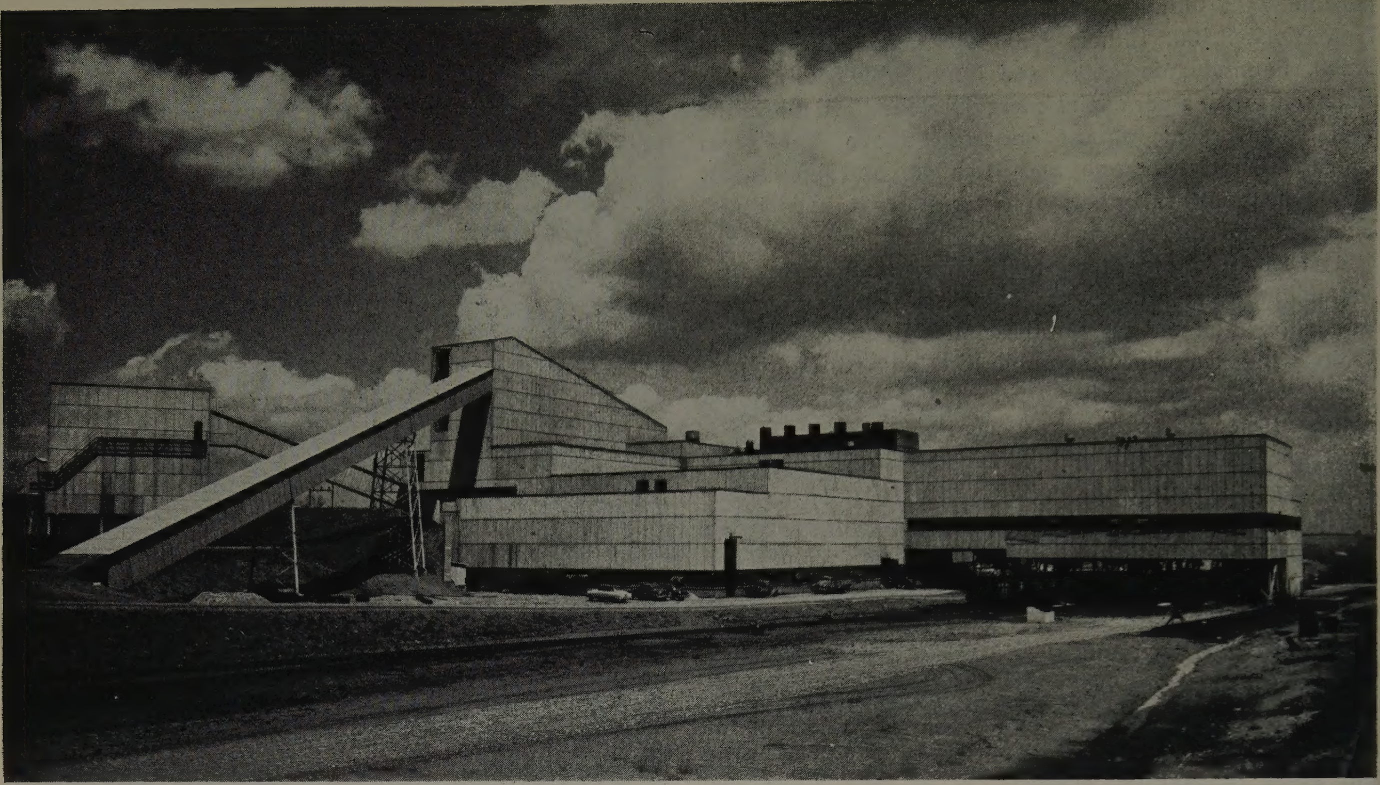

Figure 5. The Hanna Coal Company's Georgetown preparation plant at Georgetown, Ohio

already has been accomplished. A reactor adequate to drive an advanced design submarine which is well along toward completion, the *USS Nautilus*, has been built and is operating experimentally at the National Reactor Testing Station at Arco, Idaho. The keel of a second submarine, the *USS Sea Wolf*, has been laid and it, too, will be driven by an atomic power plant of a somewhat different design than that which will power the *USS Nautilus*. Other reactors for the propulsion of naval war vessels are in process of development. And any one of these reactors could be put to work to generate power for peacetime use in the home, on the farm, and in industry in Ohio—except for one thing, the item of economics.

The Chairman of the Atomic Energy Commission put the matter very succinctly in his remarks a few weeks ago:

> "Power reactors have been built and they work. Before another year rolls around, the *USS Nautilus*, our first atomic submarine and the first mobile atomic power plant, will have had her trial runs and will be in the list of operating Naval units. She will shortly be followed off the ways by the *USS Sea Wolf*."

Chairman Strauss then added this important qualification:

> "The Naval atomic energy units do not have to meet present competition with diesel fuels, of course, because of other great tactical advantages of atomic power plants. These include the ability to operate submerged for long intervals, and to cruise at speed for many thousands of miles without refueling. On the other hand civilian atomic power must justify itself by being competitive in cost with present power sources."

So we see that while atomic power has been proved, atomic power that can take its position in the market place and meet the test of competition with other forms of energy is another matter. While it is not likely to be here for some time to come, that does not mean that a great deal of work is not going on to help develop it. Research and development looking toward that end is proceeding at many of the National Laboratories: Brookhaven, Knolls, Oak Ridge, Argonne, and at locations like Bettis Field and the National Reactor Testing Station at Arco, Idaho. A number of impressive foreign projects are under way: In England and in Norway reactors are in process of construction having as their objective the development of atomic power for land or peacetime use. And the last session of Congress authorized the Atomic Energy Commission to spend up to $7,000,000 appropriated for research and development for the beginning of construction of a land-based reactor for ordinary electric power production. However, no one who is familiar with power reactor technology believes that this reactor, or any other first reactor, would be able to produce electric power that approaches in cost power produced by more conventional means—in Ohio that means burning coal.

Why is this so? Very simply: There are still a great many technical problems to be solved in reactor design, in reactor vessels, that is, the shells or drums housing the reactors, in design of atomic fuel elements, heat transfer systems, fuel element life, fuel reprocessing, valving, controls—the list could be greatly extended—before we can bring the cost of reactors and atomic fuel down to the point where the energy they produce is competitive with conventionally produced electric power. I should re-emphasize that this is especially true in an area of abundant and economical coal supply like Ohio. In a good many parts of this state it may be a long time, perhaps decades or more, before atomic power is competitive with coal-produced electric power.

In attempting to solve many of the still unsolved problems we find that there is simply a bewildering number of possibilities in reactor design, each of which can produce the same technical results but with different economic advantages. The attractiveness of each, and the economic evaluation of the positive and the negative features, are probably impossible of assessment until actual systems have been built and operated. The solution of the main technical problems which confront us probably will not be achieved except in the process of building and operating actual reactor systems.

PREDICTIONS ABOUT THE IMMEDIATE FUTURE

UNFORTUNATELY, the building of nuclear reactor systems is a very expensive operation. However, we now have reached a stage of development where it appears probable that within a fairly short time this country will be well along on the way to building one or more of such test reactors designed to produce electric power. When the time for building these comes, I believe that the power companies in Ohio, and The Ohio Power Company in particular, will take their place and contribute their share to help solve these problems and help develop these prototype reactors.

In our own case, we always have felt that, as an electrical utility, serving some 540 communities in this state, we have a responsibility for everything having to do with the production and distribution of power and in the improvement of the art relating thereto. And so we are not only deeply interested in this subject, but we are prepared to devote currently a substantial amount of money and talent to developmental work in the field. Just within the past few weeks, an announcement was made of the formation of a new 5-company industrial study team known as Nuclear Power Group which has been approved by the United States Atomic Energy Commission. American Gas and Electric Service Corporation, the engineering and service organization of The Ohio Power Company, is one of the five companies comprising this group. The initial objective of the new group is to select a reactor design intended primarily for the production of electric power that can be built in the near future, and to make a preliminary economic appraisal of such a design.

Figure 6. Dragline with a 35-yard bucket in operation at the Powhatan, Ohio, mining operation of the Powhatan Mining Company, a subsidiary of The North American Coal Company

For the immediate future, therefore, I feel that our contribution should, and will, be on a scale appropriate for research and developmental undertaking, which doubtless will include moderate experimental projects. In this research and developmental work, in which, as I have indicated, we already are taking part in considerable measure and which will expand as time goes on, we expect to continue to collaborate with other concerns from our own industry in this and other states and with other industries and with the Government. This work is all part of a program out of which, some day, commercial development of electric power based upon atomic energy may open up and, therefore, development by private enterprise. When that time comes I believe that you will find that we and others in this state will be in the forefront of such activities.

OHIO'S POSITION WITH RESPECT TO ENERGY

IN THE MEANWHILE, what might Ohio do to assure its position with respect to energy availability and expansion for old and new uses? This question is not only difficult to answer, but perhaps it would be rash of me to attempt it before a group such as this. But when I consider those here assembled tonight, all of us concerned with the welfare of this state, and all of us tied together by a common concern for its further progress, prosperity, and well-being, I think we can look at the basic policies affecting energy supply followed in Ohio with considerable satisfaction. It must be that these policies have contributed tellingly to the outstanding position that Ohio occupies today, power and energy-wise, in this nation and in the world.

The policy of support and help for the coal mining activities, proper support and fair regulation of the utilities, support and expansion of the state's educational institutions where the technicians and leaders of existing and new technologies will have to be educated and trained, all of these policies have brought about Ohio's present enviable position. It is only reasonable to expect that a continuation and improvement of these same policies will assure the availability of materials, manpower, and capital to carry on the important task of energy supply with existing technologies. While actively supporting programs of expanding and improving existing power systems and technologies we cannot stand still but to do our job well we also—to paraphrase the President of the United States in his recent Atlantic City speech—must try to reduce the titanic force of the atom to the fruitful service of mankind. Such a policy and program will give assurance that when the time comes that atomic energy has developed and can be put to work beneficially it, too, will be available without loss of critical time to function creatively in the interest of all the people throughout the length and breadth of Ohio.

Numerical Solutions for Temperature Fields in Electric Coils

P. J. SCHNEIDER

THE MAXIMUM PERMISSIBLE electric loading of a coil is restricted by the allowable temperature rise in the coil cross section. In order to establish this peak loading, the designer must compute the maximum temperature or general temperature distribution that is peculiar to each new cross-section profile under design loading. A technique for computing these general temperature fields $t(x,y)$ which combines simplicity with both flexibility and accuracy is the numerical-relaxation method of Emmons and Southwell.

A toroidal coil made up of many turns of fine insulated wire is first replaced by a mathematical model having a homogeneous profile area as in Figure 1. This general profile carrying constant electric current develops Joulean heat $Q=Q(t)$ which varies with steady local profile temperature $t(x,y)$ in accordance with the variation in electrical resistivity with $t(x,y)$. The thermal conductivity of the coil material is assumed to be independent of $t(x,y)$ as some uniform value k. All generated heat conducted to the profile boundary is dissipated to an ambient medium of uniform temperature t_a, where the boundary thermal conductance is to be identified with a constant boundary film coefficient h_s. The subdivided profile next is replaced by a network of fictitious heat-conducting rods (Figure 1) each of appropriate thermal conductance K. The heat flow in each of these rods is expressed by Fourier's 1-dimensional conduction equation in finite-difference form as $\Delta q = K\Delta t = ka/l_1\ \Delta t$, wherein a is the area normal to the assumed heat-flow path, and l is the linear length of this conducting path. If boundary temperatures are unknown, then additional conducting rods are placed in the boundary and the heat loss from each boundary rod expressed by Newton's equation as $\Delta q = K\Delta t = h_s A \Delta t$, wherein A is the boundary area between two boundary nodes. Then the steady heat conducted into a general nodal point i from all adjacent nodal points j (namely; $i=1$, $j=2, 3, 4, 5$), together with the Joulean heat generated at i is given by

$$\bar{\mathbf{q}}_i = Q_i + \sum_j \Delta q_j = Q_i + \sum_j K_j \Delta_j$$

wherein $K_j = K_{j-i} = k_i(a/l)_{j-i}$ for an internal conductance, and $K_j = (h_s A)_i$ for a boundary conductance, and where $t_j = t_j - t_i$. In general, for a subdivided region of n nodal points

$$\left.\begin{aligned}
\bar{\mathbf{q}}'_1 &= \frac{Q_1}{k_1} + \sum_{\alpha}\left(\frac{a}{l}\right)_{\alpha-1}(t_\alpha - t_1)\\
\bar{\mathbf{q}}'_2 &= \frac{Q_2}{k_2} + \sum_{\beta}\left(\frac{a}{l}\right)_{\beta-2}(t_\beta - t_2)\\
&\cdot\\
&\cdot\\
&\cdot\\
\bar{\mathbf{q}}'_n &= \frac{Q_n}{k_n} + \sum_{\lambda}\left(\frac{a}{l}\right)_{\lambda-n}(t_\lambda - t_n)
\end{aligned}\right\} \qquad (1)$$

In the steady state all $\bar{\mathbf{q}}'_i$ must be zero. All t_i and t_j that satisfy the set of simultaneous linear residual equations 1 with $\bar{\mathbf{q}}'_i = 0$ can be determined rapidly by the well-known relaxation method of Southwell.

Temperature data for a toroidal coil of square profile are available from electric-coil experiments by Rogowski and Vieweg. The isothermal boundary temperature for this coil was recorded by the authors as 76.1 degrees centigrade, and the peak profile temperature was recorded as 122.4 degrees centigrade. An approximate numerical solution for this coil based on an equivalent constant thermal conductivity and Joulean heat development taken as a linear function of local temperature gives a peak temperature of 122.0 degrees centigrade to the nearest 1/2 degree. This is in substantial agreement with the experimentally measured value of 122.4 degrees centigrade.

A second numerical solution for a coil of solid circular profile with unknown isothermal boundary is shown to be in close agreement with corresponding exact temperatures computed from an exact analytical solution.

Exact analytical solutions for $t(x,y)$ are generally awkward to evaluate numerically, particularly when such solutions (if available) are designed to encompass the effects of nonuniform heat generation and thermal conductivity and unknown boundary temperatures. Moreover, these exact solutions become mathematically intractable if the profile is not of simple regular shape. On the other hand, approximate numerical solutions are general enough to encompass all of these effects without a substantial loss in simplicity.

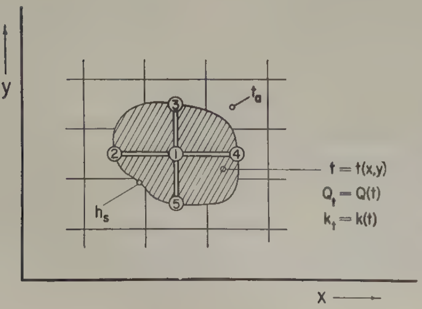

Figure 1. Network of heat-conducting rods for numerical solution

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Digest of paper 53-352, "Temperature Fields in Electric Coils—Numerical Solutions," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Stereophonic Recording Equipment

R. J. TINKHAM

IT WILL be noted that the title of this article contains the adjective "stereophonic" instead of the more commonly used "binaural." For a clearer understanding of why this word was chosen, perhaps a momentary lexical detour is in order.

It is inevitable that man in his progress of communications from talking, telephoning, aural and visual broadcasting by radio, should go back a bit to do something more than merely transmit intelligence. This is about a refinement: reproducing recorded sound more faithfully than heretofore.

"Binaural" is defined in "Websters' Unabridged Dictionary" as "Having or relating to two ears; involving the use of both ears." This, then, is purely a subjective term relating to one's inner-self. "Stereophonic" may be defined as "Giving a 3-dimensional effect of auditory perspective; of sound reproduced." This word on the other hand, is an objective term, relating to something perceived externally to one's self, as a stereoscopic picture. "Binaural" is from the Latin meaning "2-eared." "Stereophonic" is from the Greek meaning "solid sound." Perhaps we should say that we use our *binaural* sense to perceive sound *stereophonically*, or in auditory perspective.

In fact this very term, *auditory perspective*, was used throughout the six papers, presented to the AIEE in 1933 by members of the Bell Telephone Laboratories,[1] reporting their researches preparatory to transmitting the sound of the Philadelphia Symphony Orchestra in auditory perspective from Philadelphia, Pa., to Washington, D. C., in April 1933. The orchestra performed in Philadelphia, and the sound was picked up by three microphones, transmitted over three separate channels, and reproduced over three separate speaker systems on the stage of Constitution Hall. This transmission was the demonstration of the results of their research into this fascinating business of increased realism in reproduction. This was 20 years ago.

Just now engineers are becoming publically aware of the possibilities of stereophonic reproduction. This time lag is probably due to several factors. 1933 was a depression year. Such demonstrations cost money. Constitution Hall, though packed for the occasion, could accomodate only a fraction of the total population who might be interested. Only since World War II have the means been at hand of easily, cheaply, and simply recording more than one channel at a time: by the means of tape recording. It should be pointed out that multichannel tape recordings of music predated the recent interest in multichannel broadcasting. Some of the first of these recordings were made at the Summer Music Camp at Interlochen, Mich. (1951). Subsequently, 2-channel broadcasts were made in Chicago, Ill., and New York, N. Y. More recently, Standard Oil of California sponsored a series of 2-channel delayed broadcasts at San Francisco, Calif. Currently the National Broadcasting Company has had a weekly 2-channel program at Chicago and billed it as stereophonic. Several other amplitude-modulation–frequency-modulation broadcasts have been made in various parts of the United States.

The tape recordings at Interlochen were made with two microphones about 8 inches apart on two separate channels and were to be heard by means of earphones. A switch was provided to feed one of the two channels to both earphones, ignoring the other channel, to simulate monaural conditions for comparison purposes. When the switch was thrown to give the 2-channel effect, it was startling, to say the least. One seemed to be in the midst of the orchestra. And it recalled to mind the 2-eared hydrophone listening used aboard submarines in World War I, and the Bell Laboratories' "Oscar" exhibit at the World's Fair in Chicago in 1933. This exhibit, by the way, is now housed at Chicago's Museum of Science and Industry. To refresh the memory, Oscar was a life-sized dummy with two microphones hidden in his head where one's ears are normally found. He was enclosed in a glass-walled room so all could see the lecturer walk around Oscar. Several pairs of earphones were available to observers outside the room. These they donned and could both see and hear where the lecturer walked with respect to Oscar. The various auditors acoustically seemed to be where Oscar stood. But the curious point was that Oscar had his back to the audience. This, the lecturer explained, was because, as he walked behind Oscar while talking, he appeared aurally to be walking behind the auditor. And when he walked in front of Oscar, he still appeared to be walking *behind* Oscar! This was a paradox. The eyes said "yes," but the ears said an emphatic "no."

Now this condition was again evident when one listened by means of headphones to an orchestral recording. The sound, which should have been in front of the listener, was perceived to be all around him or behind him. Thus the inescapable conclusion is reached that the sound should be reproduced by means of a multiple speaker system which definitely would help the auditor localize the sound in front of himself where it logically should be. Here was this subjective "binaural" listening, as contrasted to the objective "stereophonic" reproduction.

Revised text of a conference paper presented at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953.

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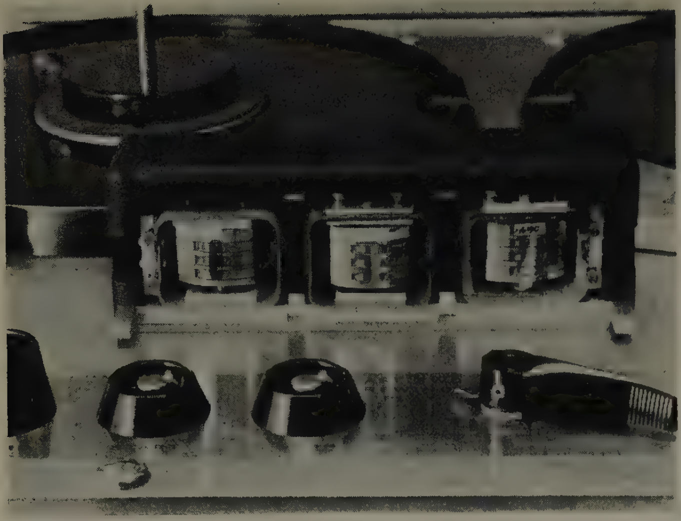

Figure 1. The head assembly of a 3-channel stereophonic recorder. The lateral displacement of the recording gaps must be held to a tolerance of ±0.0015 inch and even this amount produces a 20-degree phase error, the maximum tolerable

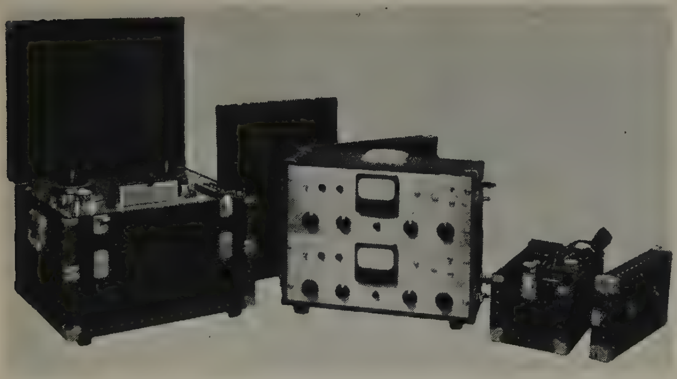

Figure 2. A 2-channel stereophonic recorder in portable cases. From left to right, the tape transport mechanism, the record and playback amplifiers for the two channels, and the power supply

Recalling the earlier experimental work back of the Philadelphia-to-Washington transmission, it was found that the researchers had explored many of the parameters involved. Using separate transmitting and listening rooms they had tried listening tests using two, three, four, and more separate channels. They also tried dividing the output of two microphones to three speakers, and of three microphones to two speakers. Phasing and loudness tests were made. Certain conclusions were reached:

One channel gave no lateral information, but did yield some depth information due to loudness changes and increased reverberation as microphone-to-source distance increased.

Two channels gave fair lateral judgement, but only poor depth determination.

Three channels gave good lateral information, by filling in at the center, and good depth information.

Four or more channels gave but little more information laterally, or depthwise, than the 3-channel system; therefore they concluded that the 3-channel system was the optimum minimum number of channels to be used for best results.

Borrowing from another channel (that is, three microphones to two speakers, or two microphones to three speakers) was only a little better than the 2-channel system and not nearly as good as the 3-channel system.

Proper phasing of all channels was a necessity to avoid cancellation effects.

Varying the relative loudness between channels made the source appear to move toward the louder reproducing point. Microphone placement must be in relation to speaker placement.

Ampex began the commercial production of multitrack tape recorders about 3 to 4 years ago for those interested in recording telemetered information from guided missiles and the like. These equipments provide any number of simultaneous channels up to 14. It was a simple step, therefore, to make stereophonic tape recorders with two or more channels.

In reviewing the literature, and customers' needs, both 2-track and 3-track machines have been built. The 2-track units have been used primarily in the industrial field where one definitely is planning to use the equipment for the purely investigative purposes of localizing and subjectively analyzing sound sources, or making sounds subjectively appear more realistic; this primarily by means of two headphones, and only rarely by means of two speakers. One track often is used also for quantitative measurement, while the other is used for running commentary. The 3-track units have been used primarily where sound is to be reproduced by means of a loudspeaker system. Obviously, only two tracks are used if headphones are to be employed.

Listening room acoustics, when using speakers, are all important, and must be taken into consideration, but this is beyond the scope of this article.[2]

In recording multichannel sound for later reproduction, all of the findings of the Bell Laboratories' experiments of 20 years ago, have not only been verified but also one other problem has been encountered. Since the Bell Laboratories' experiments were all concerned with instantaneous transmission of the original sound, time-lag effects between channels were not factors. A recorder, basically, is a time storage device. In delaying time it was found that all of the channels must be delayed by the same amount. It was thought they are all recorded side by side on the same tape, so obviously they must all be reproduced at the same time. But it was found that while all of the heads were side by side, any deviation of spacing longitudinally with respect to the direction of tape motion, introduced small constant time differences between channels. This has the effect of making the apparent location of a given source when reproduced deviate from its actual original position. The angle of deviation increases as the time differential increases, and can be calculated; therefore, all of the heads must have the smallest possible error in parallel alignment. See Figure 1.

Some manufacturers both record and reproduce using the same heads for the two functions. Here, obviously, there is no time error. But should such a recording be played on another machine, the head spacing cannot be different from the first without running afoul of this time-phase shift. Ampex uses two separate sets of heads and amplifiers: one set for recording, and one for playing back the same record an instant after it has been made. This method has obvious monitoring advantages during the recording of a program. It has the problem for the manufacturer, not the user, of making it necessary to build high accuracy into the head spacing. This problem and the one of inductive cross-talk between adjacent channels (40 decibels) have been solved.

DESCRIPTION OF EQUIPMENT

THE 2- and 3-track Ampex systems are housed in three luggage cases, as shown in Figure 2. One case contains the mechanical equipment involved in tape motion, the second contains the requisite number of combined record/playback amplifiers, each with separate controls and meter, and the third case contains the power supplies for the amplifiers. All parts, optionally, may be mounted in a standard 19-inch relay rack. The mechanical assembly is mounted on a $15^3/_4$- by 19-inch panel. Each reel turntable is driven by its own torque motor, and each motor is equipped with a solenoid-actuated brake, self-energizing in the proper direction.

A ball-bearing mounted flywheel, driven by the passage of the tape around a drum mounted on the same shaft and above the panel, stabilizes the tape motion as it approaches the head assembly. The head assembly holds, from left to right, the full track erase head, the 2- or 3-track recording head, and the 2- or 3-track playback head. See Figure 3. The heads are suitably shielded in mu-metal cans, with covers which fall into place as the hinged portion of the assembly is lowered into place after tape threading. The tape is accurately guided onto and off of the heads by means of Pyrex glass guides spaced the width of the tape apart, and appropriately at the entrance and exit of the aseembly. The tape is pulled over the heads by means of a pinch drive consisting of a capstan and rubber capstan idler roller. The capstan is the accurately ground shaft of a dual-speed hysteresis motor, and is capable of driving the tape at either $7^1/_2$ inches per second or 15 inches per second with a timing accuracy of ±3.6 seconds in 30 minutes of recording time. The capstan motor is also equipped with a flywheel. Motor speed is changed by a toggle switch. All mechanical functions—fast forward, fast rewind, stop, and playing speed forward—are controlled by means of momentary contact push buttons. Electrical memory is furnished by d-c actuated relays; therefore the entire system may be remotely controlled from a separate push-button station. Auxiliary equipment also may be plugged into the mechanism to make possible the synchronizing of the equipment with motion-picture camera and projector equipment to within 0.001-second accuracy. This is an electrical arrangement and requires no additional heads or mechanical modification to the equipment.

Each separate amplifier channel has both a recording and reproducing amplifier with appropriate switching, so that either the incoming signal on that channel, or the signal just recorded on the tape for that channel, may be monitored. (See Figure 3.) Each standard 4-inch volume-unit meter also may be switched between the recording amplifier and the playback amplifier. Erase and bias voltages for each channel also may be read on this meter through appropriate switching incorporated. The recording amplifier has a choice of three inputs: low-impedance microphone, balanced, and unbalanced bridge input. The playback amplifier delivers +8 volume units across a balanced or unbalanced 600-ohm line output. An internal 600-ohm load resistor may be cut in or out by means of a switch. Suitable gain controls are provided for each input and output. Erase and bias current is obtained from a push-pull oscillator using a toroidally wound coil and is tuned to approximately 100 kc. This oscillator is mounted integrally on one of the amplifiers. Its output is fed also to separate buffer amplifiers associated with each of the other channels. This eliminates the possibility of beats which would exist if each channel had its own oscillator.

The power supplies are straightforward. They are mounted separately to reduce hum pickup and to divide the weight into convenient packages.

On the 3-track system, the three tracks are each 0.040 inch wide and are separated by blank tape space of about 0.050 inch. All three tracks lie side by side on standard 1/4-inch-wide tape. With such narrow tracks, some signal-to-noise ratio is sacrificed. A restricted bandwidth would give less background noise. While it has been stated that a more restricted bandwidth can be tolerated when using multitrack reproduction to get the same subjective feeling of presence as compared to a monaural system, it is also true that the full auditory bandwidth will give even more realism to the sound.

CONCLUSIONS

THE NORMAL individual has only two ears; unfortunately sometimes only one, putting him at a stereo-

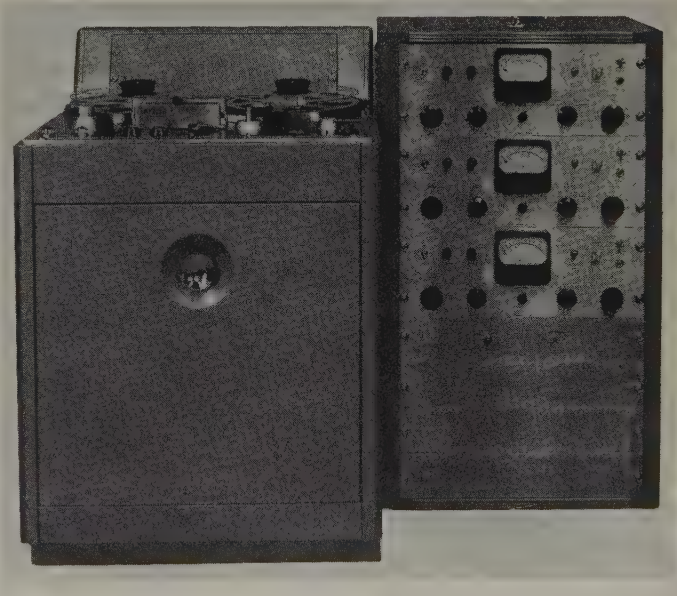

Figure 3. A 3-channel stereophonic recorder

phonic disadvantage. Having only two ears, it was at first obvious, erroneously, that only two channels need be used for stereophonic reproduction. Headphone listening, binaurally, has certain deficiencies, except for certain subjective listening studies. Loudspeaker reproduction reaches more people at a given time, and corrects some of the deficiencies of listening through headphones. But room acoustics problems, not present when headphones are used, enter here. An optimum minimum of three channels for loudspeaker listening has been established by comparative listening tests. Electrical phasing, time phasing, and balanced loudness between channels are necessary for the maximum realization of the benefits of a stereophonic system. Minimum harmonic and intermodulation distortion obviously aids any system. Transmitted bandwidth has an effect on realism also.

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Overload Relays and Circuit Breakers for Protecting Motorized Appliances and Their Branch Circuits

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MEMBER AIEE

After presenting the causes of motor overheating, thermal overload relays are discussed with bimetal-type or solder-film types being preferred. Short-circuit protection then is examined and molded-case air circuit breakers are suggested for use with most domestic- and industrial-type branch circuits to which motorized appliances are to be connected.

THE National Electrical Code, which governs the installation of all electric equipment, be it of a domestic or an industrial type, makes a clear distinction between protection against operating overloads and short circuits. Any device or circuit which is called upon to carry current in excess of its rating constitutes a fire hazard. Moderate sustained overloads weaken the insulation around the conductors, and tests have demonstrated that insulation life is approximately halved for each 8-degree-centigrade rise over the maximum safe design temperature. High overcurrents due to short circuits may cause melting and vaporization of metallic parts, thereby potentially causing a fire directly.

CAUSES OF MOTOR OVERHEATING

1. Prolonged overcurrent caused by excessive mechanical load, or by low line voltage.
2. Frequent starting of equipment not designed for duty-cycle service, or too frequent starting of equipment which is designed for duty-cycle service.
3. Excessive mechanical load causing the motor to stall.
4. Single-phase operation of a 3-phase motor caused by an open circuit in the distribution system.
5. Unbalanced voltage in the case of 3-phase motors.

In order to avoid damage to the motor, it should be disconnected from the line before it exceeds a permissible safe temperature rise. Figure 1 indicates how long a motor can operate under various amounts of overcurrent without undue overheating. This particular curve pertains to a general-purpose industrial-type 3-phase motor. Different types and designs of motors have somewhat different characteristics, but they all follow the same general kind of a curve.

MOTOR PROTECTIVE DEVICES

MOTOR PROTECTIVE DEVICES should have a tripping characteristic which follows as closely as practicable the motor heating curve so that the motor may take full advantage of its thermal storage capacity and carry an overload for a short time. On the other hand, the protective device should have such a time–current characteristic that the motor is disconnected before it reaches its temperature limit. Inherent overcurrent

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Full text of a conference paper presented at the AIEE Conference on Domestic Appliances, Louisville, Ky., April 22–24, 1953, and recommended for publication by the AIEE Committee on Domestic and Commercial Applications. Part V of a series of 5 articles. Part I "Motor Overload Protection for Domestic Appliances" by W. H. Farrell appeared in the August issue, pages 694–6; Part II "Branch-Circuit Overcurrent Protection for Appliance Loads" by F. G. Von Hoorn appeared in September, pages 778–9; Part III "The Role of Fuses in Appliance Protection" by J. C. Lebens appeared in October, pages 901–03; Part IV "Miniature Fuses for Appliance Circuits' Protection" by A. J. Steele appeared in November, pages 994–5.

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protectors and special fuses with characteristics suitable for motor protection have been treated previously in this series. This article will treat another overcurrent device which has found wide acceptance in the appliance as well as the general industrial field, namely, thermal overload relays.

THERMAL OVERLOAD RELAYS

THERMAL OVERLOAD RELAYS are replica-type relays. This means they are so designed that internally they reflect, in a miniature fashion, the same heating effects which occur in the motor. A thermal overload relay makes use of the heat-storing ability of a thermal responsive element and connected mass. The heat generated by the motor load current is conducted, convected, or radiated to the responsive element which causes the relay contact to operate when it has reached a certain temperature.

Many designs of thermal overload relays use a strip of bimetal as the heat-responsive element, which is deflected by heat. As an example, Figure 2 shows in a schematic manner a starter for a single-phase domestic refrigerator motor with built-in overload relay. When the motor is energized by the cold control, both the start and run winding are in the circuit. As the starting current drops to normal running current a solenoid with a current coil in series with the run winding opens the starting contacts and disconnects the start winding. During starting and running the overload relay is connected in series with the motor. Current flows through the bimetal strip and a nichrome heater which radiates into the bimetal strip. If sufficient heat has entered the bimetal strip, it deflects, opens the overload contacts, and disconnects the motor from the line. The overload contacts reclose automatically after the bimetal strip has cooled sufficiently to reset.

In Figure 3 the complete starter is shown. The overload relay is located to the right inside the box. This relay is manufactured for use with fractional-horsepower motors and it can be obtained in current ratings between 1.6 and 8 amperes with 10-per-cent steps between ratings. Each relay is built for a specific motor application, the difference between relays being in the heater. The relay shown is typical of a design for high production in large quantities. It is used primarily on domestic appliances.

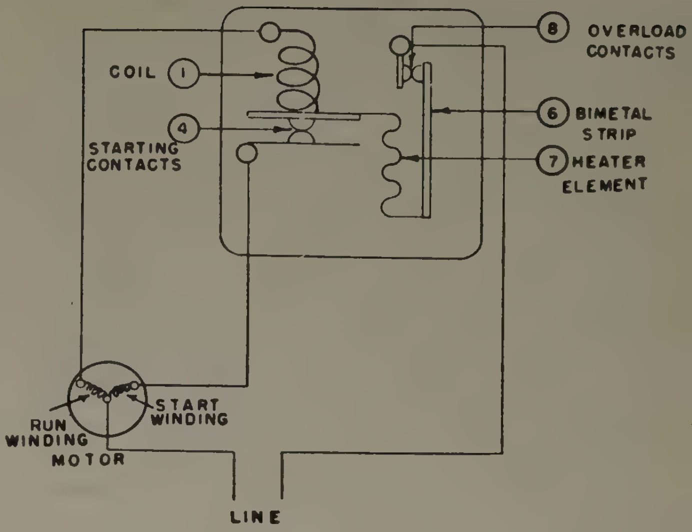


Figure 2. Schematic diagram of starter with thermal overload protection for fractional-horsepower single-phase motor

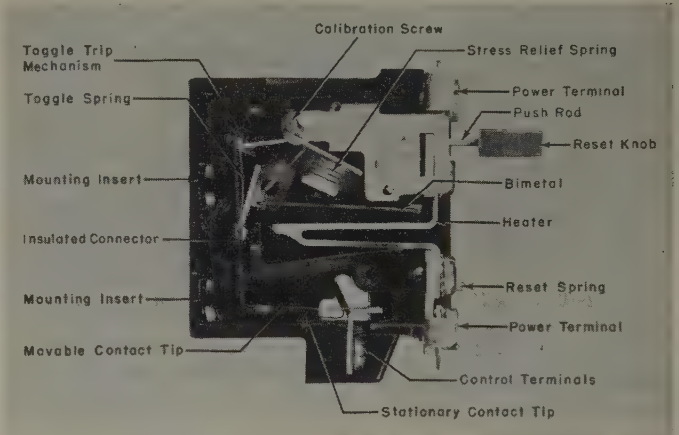
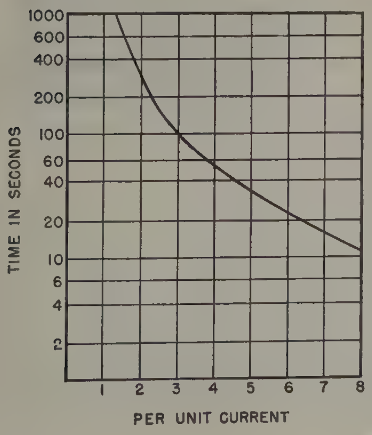


Figure 4. Single-pole thermal overload relay with interchangeable heater for industrial-type magnetic starters



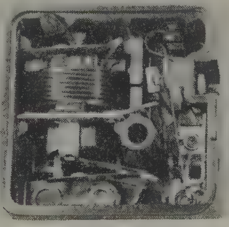


Figure 1 (left). Typical a-c motor heating curve. Figure 3 (above). Starter with thermal overload protection for fractional-horsepower motor

Larger appliances requiring integral-horsepower motors utilize a more industrial type of equipment. Quantities produced are often too small to make it economical to develop special overload relays for a given application. A general-purpose relay designed for thermal protection of any kind of industrial motor is shown in Figure 4. Motor current flows only through the heater, not through the bimetal strip. When the strip is heated sufficiently, it deflects, trips a latch, and a spring-loaded toggle mechanism opens the relay contact, which opens the coil circuit of a magnetic starter. The contacts may be reset automatically, or they may be reset manually by pressing a reset knob. One relay in one motor line is used to protect single-phase motors, and two relays in two motor lines are used to protect 3-phase motors.

The relays without the heaters are built in quantity as a standardized product. For each motor application, a different heater is used. It would be uneconomical to develop different heaters for each different motor current rating. Manufacturers have laid out their heater lines with 10-per-cent steps between heaters. When the relays are used with 40-degree-centigrade-rise general-purpose motors, which have a 115-per-cent service factor, relay heaters selected in accordance with standard heater tables as published by the manufacturers will take the motor off the line when its current is between 115 and 125 per cent of its rated full-load current. When relays are used with 50-degree-centigrade-rise rated motors, which have no service factor, heaters are chosen from a standard table for 90 per cent of motor full-load current.

A tripping characteristic of such a relay is shown in Figure 5. It trips ultimately at 115 per cent of rated motor current. In order to provide stall protection, under which condition general-purpose 3-phase squirrel-cage motors draw about 600 per cent current, thermal relays should trip in less than the time it takes the motor to attain its maximum permissible temperature rise.

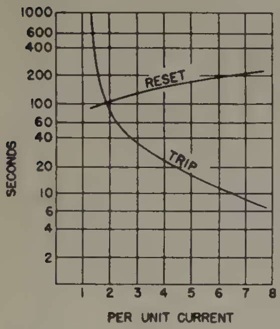


Figure 5. Tripping characteristic of thermal overload relay

Since motor heating and relay tripping are temperature problems, special relay selections may have to be made for motor operation in an ambient different from the normal 40 degrees centigrade. A peculiar problem exists when thermal overload relays are used for the protection of hermetically sealed refrigeration compressors. A hermetically sealed compressor consists of a mechanical compressor driven by an electric motor, both of which are enclosed in the same housing, the motor operating in the refrigerant atmosphere. Squirrel-cage a-c motors are used on such machines. Because they operate at lower than the normal 40 degrees centigrade ambient temperature, they can deliver a higher output, and they can draw higher current than that corresponding to their normal open rating, without exceeding the permissible maximum temperature of the motor windings. Hermetically sealed compressors have their name plates marked with the current which the motor draws while driving the compressor. This increase in running current rating of a motor of a given frame size does not have any effect on the locked-rotor current which remains the same as during normal motor operation in the open. When a motor of a given frame size is used on a hermetically sealed compressor, the ratio of stalled current to normal running current is considerably less than the approximately 600 per cent which can be expected on general-purpose motors when used in normal ambients.

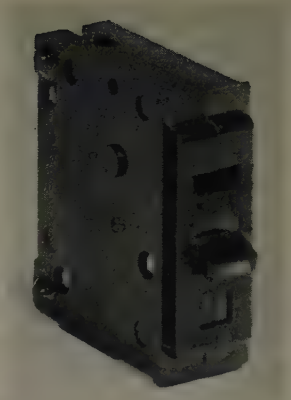
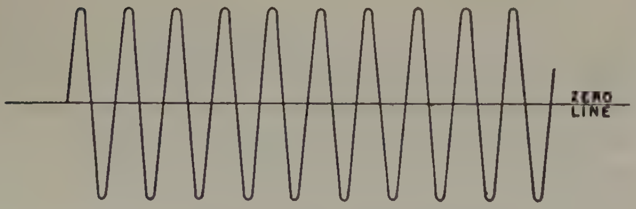
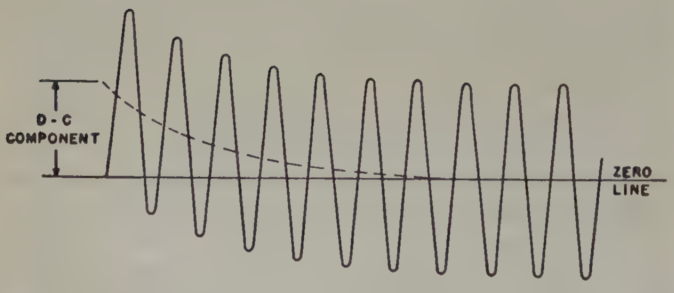


Figure 7. Molded-case air circuit breaker, single pole, 120 volts, 50-ampere frame, with 5,000-ampere interrupting capacity



A - SYMMETRICAL SHORT-CIRCUIT CURRENT



B - ASYMMETRICAL SHORT-CIRCUIT CURRENT

Figure 6. Short-circuit currents

If a thermal-overload relay were selected from a normal general-purpose relay table, it would have to be selected for a current rating corresponding to the compressor-current rating. Hence, a motor of a given frame size would be protected by a relay with a heavier heater than would be used for the same motor in a normal ambient. Consequently, under a stall condition, the relay would require a longer time to trip, and some motors may be damaged by excessive temperature rise. Hence, relay manufacturers have developed special relays with special heaters for use with hermetically sealed compressors. Such relays have a shorter tripping time at high currents than normal relays.

While this article has described specifically bimetal-type overload relays, another type of thermal-overload relay is available which makes use of a solder film to restrain operation of the relay contacts. The heater softens the solder which, when melting, releases a spring-loaded trip mechanism. Solder-film relays can be obtained with hand reset only, and they cannot be used on applications which would prefer automatic resetting.

SHORT-CIRCUIT PROTECTION

The Code requires that every motor branch circuit be protected against the devastating effects of short circuits. Fault currents which may flow in a branch circuit do not depend on motor size but on the characteristics of the power system to which the motor is connected. The short-circuit current which may flow at the point of motor installation is given by circuit voltage divided by the impedance of the power system to the point where the fault may occur. This short-circuit current is often expressed as a symmetrical rms short-circuit current. The actual current flowing in a faulted branch circuit, however, may be an asymmetrical current as illustrated in Figure 6. Depending on the instant at which the fault occurs, the current wave may be offset by a d-c component which decays exponentially to zero within a few cycles. During any fault the current actually flowing may be somewhere between the symmetrical and the fully offset value.

It is customary to rate low-voltage interrupting devices in terms of available asymmetrical current, including the d-c component that may exist at the instant of current interruption. The asymmetrical interrupting rating of the device is taken as 125 per cent of the symmetrical current representing the average of the three asymmetrical currents at 1/2 cycle after the fault has been established. This means that a circuit-interrupting device should be employed which has an interrupting rating, expressed in rms amperes, of not less than 125 per cent of the calculated symmetrical rms short-circuit current which may flow in the branch circuit. As an example, if the calculated rms short-circuit current is 4,000 amperes, the interrupting device should have a rated interrupting capacity of 5,000 amperes.

Branch circuits in dwellings and the like, where domestic appliances may be connected to 115-volt combination lighting and motor branch circuits, short-circuit currents might not exceed 1,000 amperes, and they seldom exceed 4,000 amperes. Hence devices capable of interrupting 5,000 amperes provide adequate protection for such circuits. In metropolitan areas served by large secondary networks, much higher short-circuit currents may be encountered. Symmetrical rms short-circuit currents up to 12,000 or more amperes are possible, which means that devices having an interrupting rating of 15,000 amperes or more should be considered for such applications.

Interrupting capacities of such magnitude are utterly beyond the capabilities of motor starters as are used in conjunction with appliances. Short-circuit protection must be accomplished by entirely separate devices. Two kinds of devices are recognized by the Code as being suitable for short-circuit protection, namely, circuit breakers and fuses.

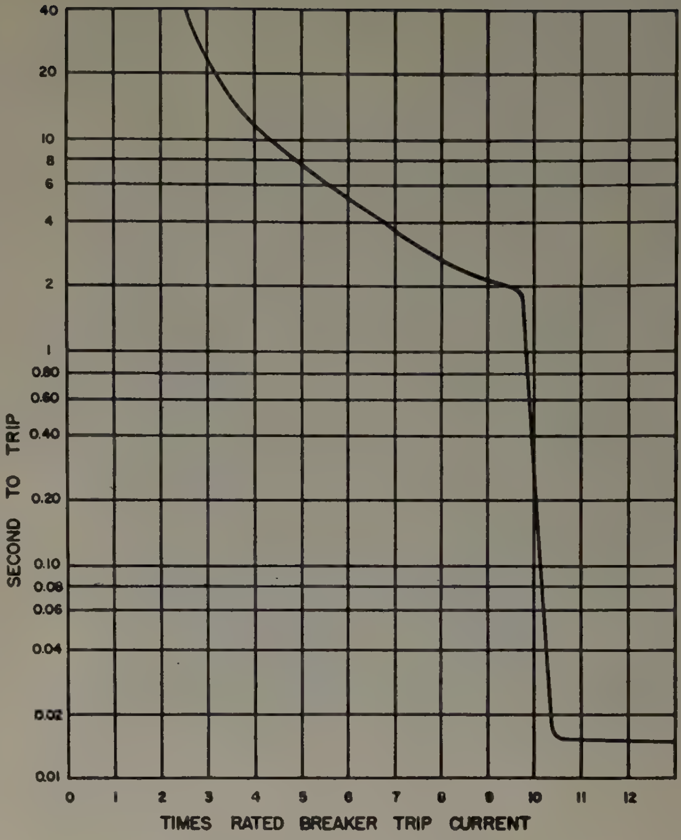
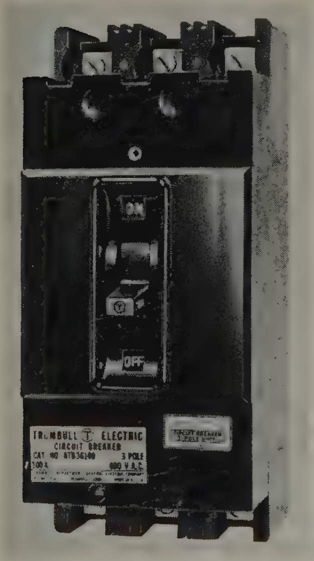


Figure 9. Tripping curve of molded-case air circuit breaker with thermal-magnetic trip



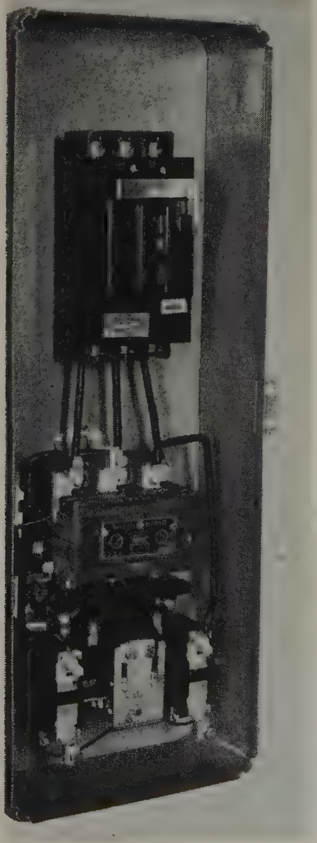


Figure 8 (above). Molded-case air circuit breaker, triple pole, 600 volts, 100-ampere frame, with 15,000-ampere interrupting capacity. Figure 10 (right). Combination starter with molded-case air circuit breaker

MOLDED-CASE AIR CIRCUIT BREAKERS

THE MOST COMMONLY USED breakers in small-capacity low-voltage circuits are the molded-case air circuit breakers. Their name is derived from their mechanical construction. The contacts, the closing mechanism, and the trip elements are completely enclosed in a molded housing. They are equipped with thermal, magnetic, or thermal-magnetic trips. At moderate overloads, they trip with a time delay, thus they do not trip on motor starting currents. Under short-circuit conditions those breakers equipped with magnetic or thermal-magnetic overcurrent elements trip instantaneously, the total interrupting time varying between 1/2 and 3 cycles, depending on breaker size.

Circuit breakers can be obtained in single-pole, double-pole, or triple-pole forms. The Code prescribes that a pole with a trip element be connected in each ungrounded line to the motor. Molded-case breakers are available in four frame sizes, having a maximum rating of 50, 100, 225, and 600 amperes. For each frame size several trip ratings can be obtained as shown in Table I.

Code rules, which have been established on the basis of long years of experience, govern the selection of breaker current ratings for motors of various sizes. The following rules apply to squirrel-cage motors with full-voltage starting

Table I

Frame Size, Amperes	Trip Ratings, Amperes	Tripping Time, Cycles
50	10, 15, 20, 30, 40, 50	½*
100	15, 20, 30, 40, 50, 70, 100	1*
225	70, 100, 125, 150, 175, 200, 225	1½–3
600	125, 150, 175, 200, 225, 250, 275, 300, 350, 400, 500, 600	1½–3

* Approximately.

which represent the bulk of the motors used on appliances.

1. For motors having a code letter, the current rating of the breaker should not exceed the following per cent of motor full-load current:

Code letter *A*.........150 per cent
Code letters *B* to *E*....200 per cent
Code letters *F* to *V*....250 per cent

2. For motors which do not have a code letter, the current rating of the breaker should not exceed 250 per cent of motor full-load current.

Certain exceptions are permitted by the Code in case of high-inertia drives and the like which could not be started with breakers selected under the foregoing rules. However, in order to protect the thermal overload relays against damage due to short circuits, the breaker current rating never must exceed 400 per cent of the motor full-load currents.

Shown in Figure 7 is a single-pole circuit breaker which is designed to meet the requirements of protecting general lighting and appliance branch circuits of the domestic or commercial type. This is a 50-ampere frame for use on 120-volt a-c circuits. Double-pole breakers also can be obtained for use on 120/240-volt circuits. Double-pole breakers consist of two single-pole units clamped together with a common operating handle. The interrupting rating of this type of breaker is 5,000 amperes rms, which is ample for conditions encountered in most dwellings, office buildings, and similar locations where fractional-horsepower motor-driven appliances generally are found. This is the same type of breaker which often is assembled into load centers and panelboards.

Larger appliances which are driven by integral-horsepower polyphase motors may have to be connected to branch circuits serving motor loads only. Industrial-type circuit breakers are used in such cases. Figure 8 illustrates a circuit breaker, triple pole, 100-ampere frame, designed for use on circuits up to 600 volts. The interrupting rating of this type of breaker is 15,000 amperes which makes it usable on most industrial low-voltage motor branch circuits on which appliances may be found.

Figure 9 is a typical tripping characteristic of a molded-case breaker, indicating in a general manner the tripping time for various amounts of current, expressed in terms of breaker trip-current rating. This curve is generalized for a whole line of breakers, and individual breakers will deviate somewhat from that curve. Manufacturers have published in their catalogues information on the bandwidth of the tripping characteristics of their breakers, and more specific information on particular breakers may be obtained upon request. For overcurrents up to approximately 10 times breaker rating the trip curve is a conventional inverse-time curve while the breaker is under the control of the thermal trips. At approximately 10 times rated breaker current the magnetic trips take over. The breaking point in the trip curve may vary between about 9 and 15 times breaker trip current rating, depending upon breaker size.

The Code does not establish specific rules on where the circuit breakers are to be located. They may be installed on a power distribution switchboard. They may be installed as individual units ahead of the motor starter. When large appliances with polyphase motors are controlled by magnetic starters, short-circuit protection may be built into the starter by the use of a combination starter. Such a starter, as illustrated in Figure 10, consists of a conventional magnetic starter (line contactor with built-on overload relays) and a circuit breaker mounted in a common enclosure. Combination starters up to National Electrical Manufacturers Association size *4* are suitable for installation in motor branch circuits in which the available asymmetrical short-circuit current does not exceed 15,000 amperes. All parts of the starter, including the wiring, are assembled so that they can withstand the stresses due to fault currents. Combination starters are co-ordinated motor controllers, providing in one package overload and short-circuit protection.

In conclusion, it can be stated that thermal-overload relays of the bimetallic or the solder-film variety are available from control manufacturers which provide adequate running overload and stall protection for fractional-horsepower single-phase and for integral-horsepower polyphase motors. Molded-case circuit breakers provide acceptable short-circuit protection for most domestic- or industrial-type branch circuits to which motorized appliances may be connected.

While this article deals with the role of circuit breakers as short-circuit protective devices, it should be kept in mind that fuses—treated elsewhere in this series—also are recognized as adequate means for protecting motor branch circuits against overloads. Conventional National Electrical Code fuses or current-limiting fuses with high interrupting rating are in use. Therefore, control manufacturers also offer combination starters which, instead of a circuit breaker, contain a fusible motor circuit switch for disconnecting and protecting the motor branch circuit.

Nuclear Power Study

Five companies, four of which have been participants in previous nuclear power studies, have joined in a new study which has been approved by the Atomic Energy Commission. The five companies are American Gas and Electric Service Corporation, Bechtel Corporation, Commonwealth Edison Company, Pacific Gas and Electric Company, and Union Electric Company. The initial objective of the new group is to select a design of a reactor intended primarily for the production of electric power within the near future and to make a preliminary economic appraisal of such a design.

Mine-Trailing Cables

STEVE BUNISH

Mine-trailing-cable construction is discussed with the cables being divided into five groups having characteristically different construction. The four principal types of damage to these cables are given together with ways of identifying the damage and both preventive and remedial measures.

THE PRIMARY FUNCTION OF a trailing cable is to supply electric energy to portable equipment, such as shuttle cars, loading machines, and cutting machines. To date, no one group of materials can be used to build trailing cable that will satisfy all requirements. The most useful conductor is stranded copper and the most successful insulation and covering is Type *RH-RW* or equivalent and neoprene jacket, respectively.

Mine-trailing cables are sufficiently important in mine operation to justify all the development and research they have undergone and all the careful treatment their users can give them. They continue to receive a good deal of attention as to development of better cable constructions, better materials, better designed equipment for handling them, and better methods for protecting them from damage.

Mine-trailing-cable construction has undergone many changes and improvements. Some of these have been concurrent with improvement in materials and some independent of them. Some of the cable manufacturers' best engineers are working continuously for more improvement. Two laboratory testing machines are shown in the title picture and Figure 1. The former shows a laboratory machine bend testing a trailer cable 90 degrees to the left and right to total 180 degrees. The test is continued until conductor failure—the number of bend cycles to failure is recorded and becomes useful in comparing and evaluating fatigue resistance.

Improvements in design have included the cord-reinforced jacket, stranding technique, make-up of grounding conductors (flat for twin cables, rubber-cored for round cables), protection of grounding conductors against crushing and short-circuiting, unified mechanical design resulting in improved tensile strength of the cable as a whole and greater resistance to damage from excessive tension.

MINE-TRAILING-CABLE CONSTRUCTION

TRAILING CABLES used in supplying equipment at the mining face or in transporting material from the face can be divided into five groups, each with characteristically different constructions.

1. *Gathering Locomotive Cable.* It is made up with a single flexible insulated conductor. A reinforcing web or open braid is placed over the insulated conductor. This core then is covered with a tough protective sheath or jacket, see Figure 2. This construction was designed to withstand the constant reeling, bending, and rough usage encountered in the operation of a gathering locomotive.

2. *Flat Twin—With and Without Grounding Conductor.* In flat-twin construction, two flexible insulated conductors are laid parallel. If a grounding conductor is desired, it is positioned between the two insulated power conductors. Reinforcing members—such as rubber fillers, braids, webs, or breaker strips—are placed with or around the parallel members. This core is covered with a tough jacket. A special shape of conductor insulation is shown in Figure 3, but it also may be round. Flat-twin cables are the most popular construction used on face-mining equipment. They are made in a wide range of sizes and can fill most power requirements. They are designed to withstand bending around small-diameter sheaves, cable drums, and guides. The parallel construction offers considerable resistance to run-overs and physical abuse.

3. *Round Multiple Conductor—Types W and G.* Type *W* cables are made up with either three or four flexible insulated conductors. Identification is by colored compounds or by tape or braids over black insulation. The core is protected by two jackets with a reinforcing web or open braid between them, see Figure 4. Type *G* cables are similar to Type *W* cables except that grounding wires are placed in the interstices. Round multiple-conductor cables are used on a-c equipment.

Condensed text of a District paper, "Construction and Maintenance of Mine-Trailing Cables" presented at the AIEE Middle Eastern District Meeting, Charleston, W. Va., September 29–October 1, 1953.

Steve Bunish is with Anaconda Wire and Cable Company, Marion, Ind.

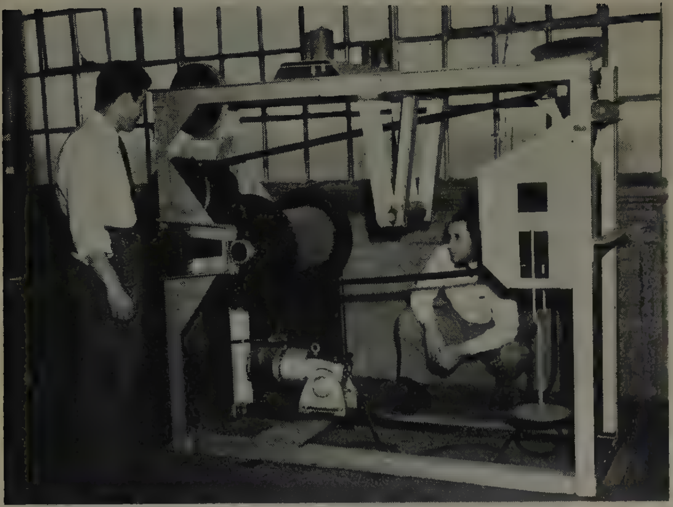


Figure 1. Laboratory testing machine for simulating action of mine-trailing cable on portable mine equipment. Cable is bent around a cable drum and through a series of sheaves. The machine is also useful for evaluating fatigue resistance

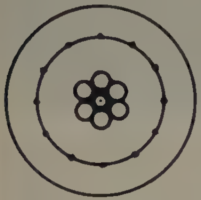
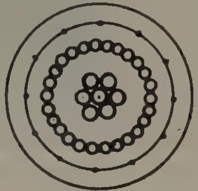


Figure 2 (left). Gathering locomotive cable. Figure 5 (right). Concentric mining machine cable



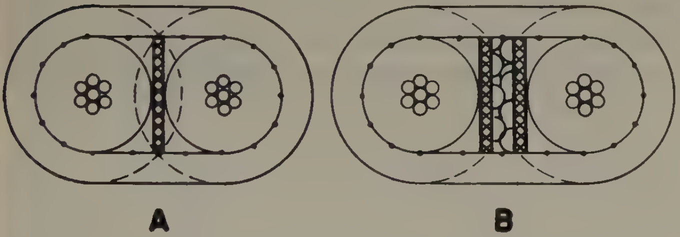


Figure 3. Flat twin: A. With breaker strips; B. With grounding conductor and breaker strips

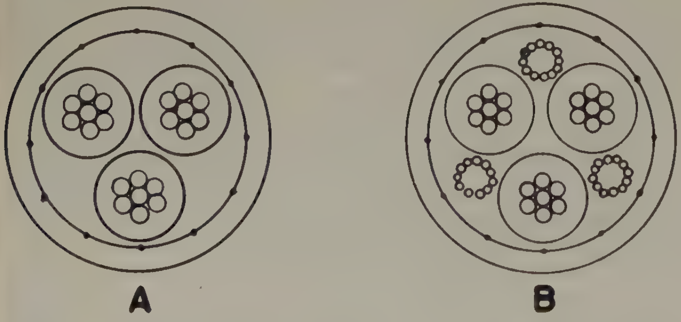
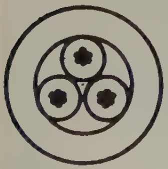
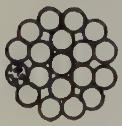


Figure 4. Round multiple conductor: A. Type W; B. Type G





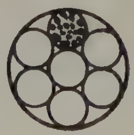


Figure 6 (left). Heavy-duty drill cord. Figure 7 (center). 133-wire strand with 19 ropes of 7 wires each (19 × 7). Figure 8 (right). 133-wire strand with 7 ropes of 19 wires each (7 × 19)

4. *Concentric Mining-Machine Cable.* In a concentric mining-machine cable, individual wires are stranded concentrically around a flexible insulated conductor. A reinforced covering then is applied around this core, see Figure 5. Concentric mining-machine cables find limited use on gathering locomotives and other mining equipment. They have the advantage of small diameters but they are not designed to take the twisting, bending, and physical abuse that trailing cables receive in modern mining.

5. *Heavy-Duty Drill Cords.* Heavy-duty drill cords are made up with flexible insulated conductors, cabled together with appropriate fillers. They then are covered with an extra-heavy jacket. This extra-heavy jacket offers additional protection against physical abuse, see Figure 6.

All cables are basically one or more conductors with electrical insulation and a protective jacket. The heart of any trailing cable is the stranded conductors made of stranded annealed copper wires.

FLEXIBLE STRANDING

Two important factors to consider in designing a flexible copper conductor for mine-trailing cables are

1. The size and number of individual wires to use to obtain the desired cross-sectional area of copper and the necessary flexibility. Generally and within limits, the smaller the wire size, the better the conductor flexibility.

2. The direction and length of lay of both the individual ropes in a conductor and in the final stranded conductor. These factors play an important part in the mechanical behavior of the cable. Mine-trailing-cable conductors usually are made up with 133 wires or with 259 wires. These can be stranded in a variety of ways. For example, a 133-wire strand can be made up in the following ways:

A. Nineteen ropes of seven wires each (19 × 7). In this construction, one rope is used as a core. Six ropes then are stranded concentrically around this core. This is followed by another layer of the remaining 12 ropes. The individual ropes can be concentrically stranded or bunched, see Figure 7.

B. Seven ropes of 19 wires each (7 × 19). In this construction one group of 19 wires is used as a core. The remaining six ropes are stranded concentrically around this core. The individual ropes can be concentrically stranded or bunched, see Figure 8.

LAY OF STRANDED CONDUCTORS

The direction in which copper wires are stranded also can be varied. Typical designs are as follows:

1. *Standard Lay.* The lay of the individual ropes in any one layer of the stranded conductor is the reverse of the lay of the layer. The lay of each layer is alternated; right hand—left hand. The final layer is usually left-hand lay.

2. *Unidirectional Lay.* In this construction the individual wires making up each rope are stranded in the same direction as the final stranded conductor.

3. *Herringbone Lay*. This type of lay usually is used in a 7 × 19 or 7 × 37 construction.

The direction of lay is reversed in alternate ropes in the outer layer.

Whenever a trailing cable is in service, the stranded-copper conductors are subjected to compression, shear, torsion, and tensile stress. Stranded conductors with a standard lay and made up with seven ropes seem to give better service than 19-rope constructions.

A Herringbone lay often is used in single-conductor gathering-locomotive cable constructions. The location and action of the locomotive cable reel subjects a cable to considerable torsion. Herringbone lay seems to balance these torsional stresses when a gathering-locomotive cable is reeled and unreeled. Unidirectional lay is seldom used in electric conductors. This type of lay is used in some steel-rope constructions.

For the ultimate in mechanical performance, which feature is predominant in mine-trailing cables, the foregoing points all must be considered in designing a cable which will have fatigue resistance and a proper balance between various metallic components. This is so that under severe tension, a grounding conductor, for example, will not break before the power conductor.

INSULATION

Insulations for mine-trailing cables should have the following characteristics:

1. Adequate electrical properties.
2. Physical toughness: high resistance to compression cutting.
3. High resistance to oxidation and deterioration from heat. The majority of cables used on face equipment are rated at 600 volts. These insulations at present are for the most part made up of Buna *S* (*GRS*) compound.

Heat-resistant grade insulations meeting American Society for Testing Materials Specification *D 754* make a quality insulation for trailing cables. They are characterized by long life, high electrical values, and good mechanical properties. The maximum permissible copper temperature for cable insulated with heat-resistant grade is 75 degrees centigrade.

Past experiences have shown that natural rubber insulations generally become soft and plastic at very high temperatures. These high temperatures were reached when trailing cables were electrically overloaded. Buna *S* compounds make desirable trailing-cable insulations because they do not exhibit this tendency. At temperatures up to 100 degrees centigrade they do not have the mechanical strength of natural rubber compounds but at much higher temperatures they are better.

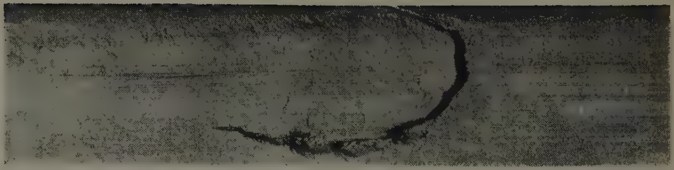


Figure 9. Snagged and torn jacket

Figure 10. Jacket damaged by excessive abrasion

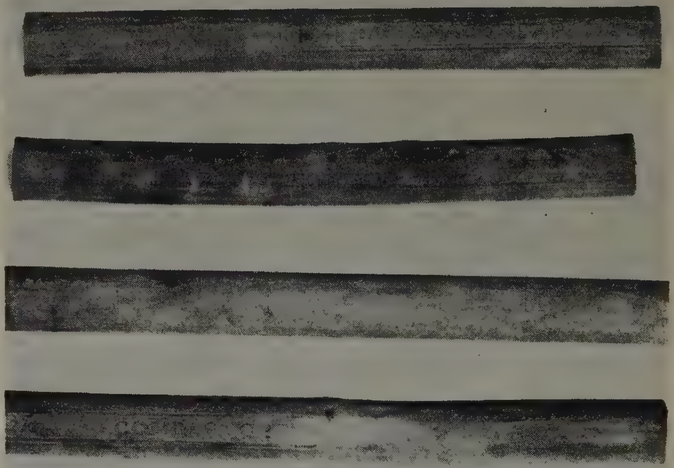
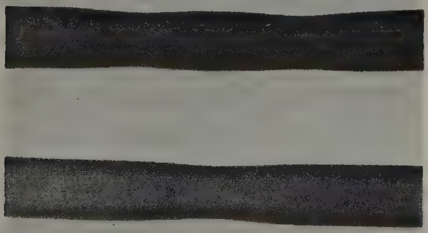
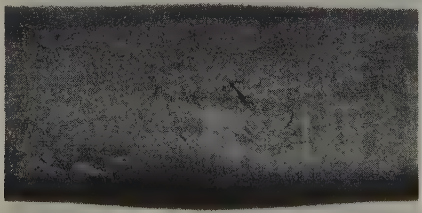


Figure 11. Unrepaired punctured trailing cables which would cause electrical failures in wet sections

JACKETS

The protective coverings or jackets of trailing cables should be highly resistant to acid mine waters, oil,





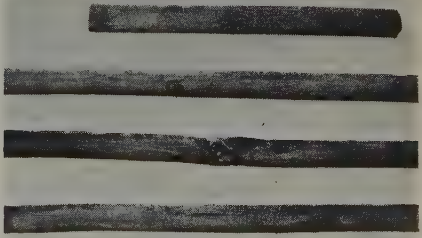


Figure 12 (left). Cable subjected to excessive tension shown by the hour-glass shape. Figure 13 (center). Cable crushed sufficiently to cause variation in its diameter. Figure 14 (right). Cables badly cut and crushed. The third specimen from the top was almost severed

mud, and grease. They should have good flame resistance. They should be characterized by physical properties that include high resistance to abrasion, compression cutting, and tearing.

The most widely used rubber for jackets is neoprene. Its inherent chemical properties give it good flame and acceptable oil resistance.

PRINCIPAL CAUSES OF DAMAGE IN MINE-TRAILING CABLES

MINE-TRAILING-CABLE DAMAGE, it can be shown, is neither mysterious nor unaccountable. Aside from manufacturing deficiencies which occasionally will occur, damage can be divided into four categories. All these four can result in partial or complete rupture of the insulation and consequent interruption to service. Partial cases become complete if the opportunity for additional damage is not removed. The four categories are: 1. Excessive tension. 2. Mechanical damage. 3. Electrical overload. 4. Poor joints and terminals.

Excessive Tension. One of the outstanding causes of damage is excessive longitudinal tension. Even with tension devices on the mining machine, it is possible to get sufficient tension to damage cable jackets and break conductors.

A good indication of excessive tension is necking down (into hour-glass shape) of a portion of cable. This condition seems to occur much more frequently in smaller cable sizes. When copper conductors are stretched, considerable tension is exerted before any appreciable elongation takes place. A stranded-copper conductor will elongate approximately 20 per cent before rupture. Once the conductor stretches, it does not return to its original length.

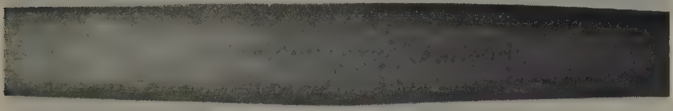


Figure 15. Blisters formed under the jacket by electrical overload

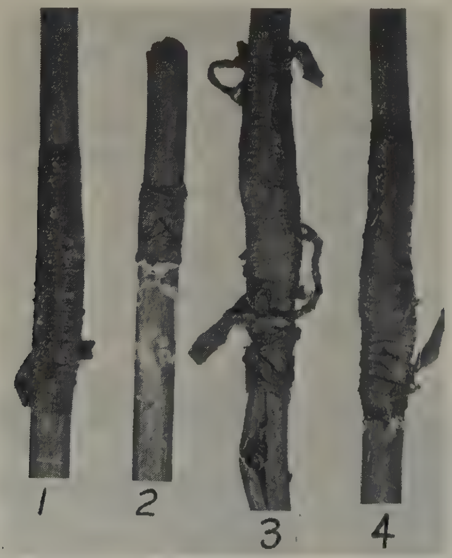


Figure 16. Troubles resulting from unsatisfactory temporary repairs and joints on trailing cables: Numbers 1 and 2 show jacket repairs made with friction tape; in numbers 3 and 4 the conductors have been spliced; in number 3 the grounding conductor was cut and left open and one insulated conductor was left exposed

Table I. Suggested Trailing-Cable Maintenance

Cause of Damage	Evidence of Damage	How to Avoid Damage
1. Excessive tension	Cable necked down resembling hour-glass shape, or Jacket creeping back from temporary joint, or Grounding conductor pulled apart	Install spring-type shock absorber at power source, and Keep proper tension on trailing cable reel, and Adjust cable reel to prevent back spooling
2. Mechanical damage	Short sections of cable crushed or flattened to a larger diameter along major axis, or Excessive abrasion, or Gouges, cuts, punctures	Avoid run-overs, and Replace broken sheaves or guides, and Avoid pinching cable between equipment and rib, roof, or mine bottom
3. Electrical overload	Blistered jacket, or Jacket hardens and cracks on bottom layer on reel, or Tinned-copper strands turn blue-black	Choose cable with adequate current rating. Consult cable manufacturer or mining machine manufacturer for recommendations, and When cable is removed for making permanent joints, reverse cable ends, and When operating only a short distance from power source, remove cable from reel and place it where it will be well ventilated
4. Poor temporary joints and terminals	Exposed conductors in a joint	Carry insulating tapes back over original conductor insulation and replace temporary with permanent joint as soon as possible
	Open grounding conductor	Make conductor continuous in all joints and ground it at all terminals
	Kinked cable	Balance the conductor lengths in all joints and terminals so that all are under even tension

Mechanical Damage. Whenever a trailing cable in service is grooved, shows uneven wear, or is abraded deeply in localized areas, it is a good indication that it has suffered mechanical abuse beyond the limits for which it was designed. A jacket which has been snagged and torn is shown in Figure 9. This type of abuse can go undetected electrically for some time because the conductors still are separated physically. As soon as it is located, a thorough repair job should be done.

Excessive abrasion can damage the cable jacket as seen in Figure 10. Whenever a cable is grooved or abraded deeply in localized areas or shows uneven wear, it is good evidence that it has suffered mechanical abuse beyond the limits for which it was designed.

Punctures, another type of mechanical damage, are shown in Figure 11. All four of these trailing cables were not repaired after being punctured. In wet sections, electrical failure would result.

Another form of mechanical damage results from excessive tension, see Figure 12. One way it may be indicated is by necking down in hour-glass shape. The cable must be stretched almost to its ultimate strength before this can occur.

Crushing can result in varying degrees of damage. Figure 13 shows a jacket which has been crushed to such an extent that variation in its diameter can be detected easily. This crushing can be the result of running over or pinching the cable. Cutting combined with crushing can result in severe damage as shown in Figure 14.

Electrical Overload

1. Causes of overload:

A. Selection of conductor size too small for the ampere load to be carried under the conditions the cable must meet.

B. Operation at low voltage, aggravated by excessive cable length.

C. Accumulation of excessive heat due to one or more layers of cable on a reel.

D. Inadequate or nonoperating overload protection.

Reduction in current rating for number of layers on a reel always should be allowed, otherwise the cable will be under the handicap of overload and excessive temperature from the beginning, a great deterrent to long life. The Insulated Power Cable Engineers Association recommends that "when cables are used with one or more layers wound on a gathering reel, the current-carrying capacities shall be corrected as follows":

Number of Layers on a Gathering Reel	Corrected Value of Current-Carrying Capacity: Multiply Specified Value by the Appropriate Factor Below
1	0.85
2	0.65
3	0.45
4	0.35

It may appear wrong at first, when one reads "one or more layers." Actually, the current rating is based on one cable in air, without anything near it to prevent natural movement of air adjacent to its surface. When a cable is wound on a reel, even in one layer, it is no longer able to depend upon full natural ventilation, heat is not removed so rapidly, so the current rating must be reduced.

2. Results of high electrical overloading:

A. Temperature of conductor, insulation, and jacket all are elevated, sometimes to dangerous values.

B. Resistance of the copper conductor is increased, voltage drop in the cable is increased and a reduced voltage is supplied to the machine, automatically calling for more current which adds to cable heating.

C. Insulation and jacket are much more vulnerable to physical damage, such as cutting and tearing. Electrical overload can be evidenced by the formation of blisters under the jacket as shown in Figure 15. These blisters are formed by gases given off by rubber compounds upon being raised to an elevated temperature. They increase the cable diameter and make it more susceptible to damage.

D. Entire cable becomes a definite fire hazard under extreme conditions of overloading, such as stalled motors. The conductors are well overheated.

Poor Joints and Terminals. Either can reduce the effectiveness of a trailing cable. It can become an operating liability. The most common examples of poor jointing technique in making temporary joints are

1. Cutting out the grounding conductor, leaving it open and partly ungrounded, see Figure 16.

2. Failure to cover conductor completely with insulating tapes, leaving bare wires exposed, see Figure 17.

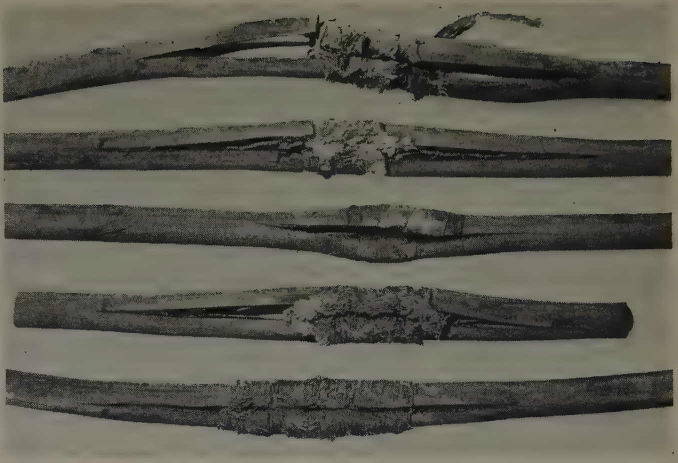


Figure 17. Unsatisfactory joints: Little effort was made to carry the insulating tape back over the original insulation and jacket in three of these temporary joints. However, water easily can enter all five

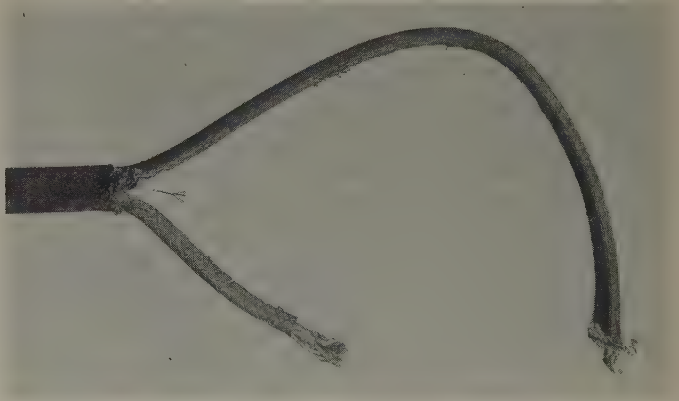


Figure 18. The grounding conductor in this trailing cable terminal was not connected. The individual conductors also should be of equal length and so attached to the terminal apparatus that even tension occurs on both conductors to prevent kinking which can damage the cable

3. Failure to balance the length of individual conductors at joints, resulting in uneven tension on conductors, see Figure 18.

4. Individual wires cut or broken during jointing operation.

The grounding conductor at the terminal of a trailing cable always should be connected to ground. Failure to do so defeats the purpose of the grounding conductor.

CONCLUSIONS

1. Present methods of trailer-cable construction are very helpful but not sufficient to prevent damage, especially from rough usage. In the long run, the way in which the user handles the cable determines how long it will last.

2. Recognition of physical and electrical limitations of trailer cables and action accordingly will result in cables receiving less abuse and suffering less damage. See Table I.

3. A continuous and effective maintenance program will result in less-frequent work stoppage and increase protection against damage and hazard. See Table I.

Frequency and Fluorescent Lamps

D. E. SPENCER

Although 60-cycle alternating current is almost universally employed for lighting purposes in this country, fluorescent lamps can be operated more economically on higher frequencies and at the same time their light output and life are increased.

TODAY NEARLY all electric energy is generated at 60 cycles per second. The first large generating stations were built at a time when alternating current was barely beginning to be understood. Engineers felt constrained to choose, as standard, the lowest frequency that would eliminate flicker in Edison's incandescent lamps. With the development of a better understanding of electric circuits and electromagnetic fields, the engineer finds that higher frequencies than the standard 60 are preferable in many applications. Airplane equipment is ordinarily designed for higher frequencies such as 600 cycles per second, thereby reducing the weight of synchronous equipment as compared to similar 60-cycle equipment. Electric furnaces for induction heating of metals are available at 1,000, 3,000, and 10,000 cycles per second (cps).

Though the commercial frequency was developed to meet the needs of incandescent lamps, it is unsuited theoretically to the operation of fluorescent lamps. To obtain best performance, fluorescent lamps should be operated at a much higher frequency. This article will present information recently obtained on the advantages of frequencies above 60 cps.

CHOICE OF FREQUENCY

THE PREFERABLE frequency for the operation of fluorescent lamps should be chosen after taking account of the lamp characteristics, acoustic considerations, the weight of auxiliary equipment, and transmission line properties.

Incandescent Lamps. An incandescent lamp may be considered to be a temperature-sensitive resistor.[1] The resistance depends on the temperature and consequently on the instantaneous current as well as on the previous thermal history of the filament. If a 60-watt incandescent lamp, for instance, is operated at a low frequency (say 25 cps), the filament is cooler when the current is increasing than when it is decreasing as indicated in Figure 1*A*. As a result, the current is larger on one half of the cycle than on the other half and more light is emitted in one half-cycle than in the other. There is annoying flicker.

For optimum operation of an incandescent lamp, the frequency must be increased until the period is so short that the filament does not cool appreciably during a half-cycle. The volt-ampere characteristic then approaches the shape shown in Figure 1*B* and flicker is eliminated. Dynamic thermal equilibrium of an incandescent lamp is satisfactorily approximated at a frequency of 50 or 60 cps.

Fluorescent Lamps. Under ordinary conditions of operation, the dynamic characteristics of fluorescent lamps are relatively complicated because inertia effects are comparatively small. Frequencies considerably above 60 cps are required to produce dynamic equilibrium. The mercury vapor in the tube is always partially ionized and the lamp may be considered as a resistor[1] whose conductance depends on the state of ionization of the vapor within the tube. A typical volt-ampere characteristic for a fluorescent lamp operated from a 60-cps inductive ballast is shown in Figure 2*A*. For an increasing current, the ionization is less at a given value of current than for a decreasing current. Thus the resistance is higher when the current is increasing than when the current is decreasing. The effect is similar to that shown in Figure 1 for an incandescent lamp but with two important differences:

1. The loop is traversed in the opposite direction.
2. The time of deionization of the vapor-filled tube is much smaller than the time of thermal cooling of the lamp filament.

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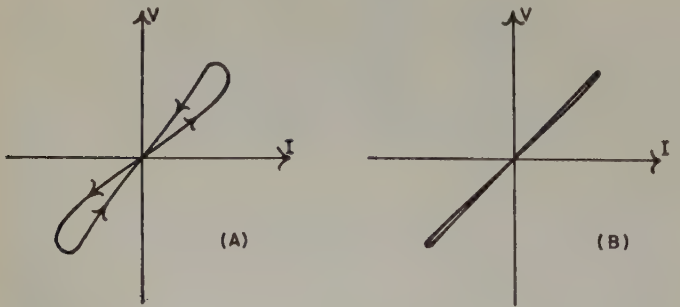

Figure 1. **Typical volt-ampere characteristics for an incandescent lamp; A, 25 cps; B, 60 cps**

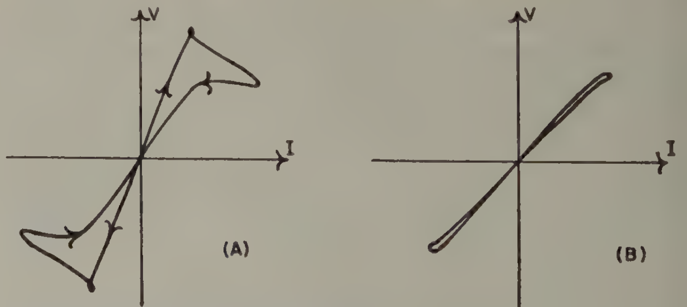

Figure 2. **Typical volt-ampere characteristics for a fluorescent lamp; A, 60 cps; B, 3,000 cps**

A linear characteristic is eventually approached in both cases, but for the fluorescent lamp the curve of Figure 2*B* does not occur until the frequency is raised to about 3,000 cps. Optimum operation of a fluorescent lamp requires that the frequency should be high enough so that the state of ionization in the discharge reaches dynamic equilibrium. This requires frequencies about 50 times as high as are employed ordinarily.

Lumen Output. If dynamic equilibrium of the ionization within a fluorescent lamp is approximated, the lamp operates more efficiently. As the frequency is raised the[2] number of lumens emitted per watt input to the lamps increases until it reaches a plateau at about 10,000 cps (Figure 3 and Table I). The maximum increase for any of the lamps shown in Table I is obtained with the "low brightness" *T-17* lamp: an increase of 13 per cent at 10,000 cps. The Campbell-Schultz-Kershaw data are in fair agreement with measurements made in collaboration with R. A. Coradeschi on 40-watt *T-17* lamps at 3,000 cps which showed an increase in lumen output of 9 per cent if lamps are operated at rated current. The lumen output per watt from the lamps is, however, in excess of the Campbell-Schultz-Kershaw values, for the power input at rated current was found to be, not 40 watts, but 37.8 watts with a resulting over-all increase in lumen output per watt input of 15 per cent.

Ballast losses are not included, of course, in the data considered in this paragraph. The use of entirely different circuits at high frequencies provides a further saving. Exclusive of ballast losses, savings can be obtained in the power supplied to the lamps for a given lumen output of 10 to 15 per cent by employing higher frequencies. The data of Figure 3 indicate that no appreciable saving will be effected by raising the frequency above 10,000 cps.

Lamp Life. The life of a fluorescent lamp is maximized by minimizing ion bombardment of the filament on starting and during steady-state operation. For long life, we need a quick start and the maintenance of dynamic equilibrium once the transient is completed. At higher frequencies the starting tends to be quicker and the starting voltage can be somewhat lower. As shown in Figure 2, dynamic equilibrium is attained. Thus the lamp life would be expected to increase when lamps are operated at frequencies above 60 cps.

Tests made in collaboration with R. A. Coradeschi on a group of 16 40-watt *T-17* lamps at 3,000 cps showed an increase of 12 per cent in lamp life as compared to a group of 6 control lamps operated on conventional General Electric *89G400* ballasts at 60 cps. As the life of fluorescent lamps depends primarily on the number of starts and only to a minor extent on the length of time the lamps are burned, an on-off cycle of 10 minutes on to 5 minutes off was used to accelerate the tests. Lamps were operated at rated current with the circuit of Figures 4 and 5. The life test should be repeated, of course, under a variety of conditions and with larger groups of lamps. It is apparent, nevertheless, that there is a definite increase in lamp life as compared to standard 60-cycle circuits. It is felt that the 12-per-cent increase obtained with the first set of life tests is, if anything, conservative.

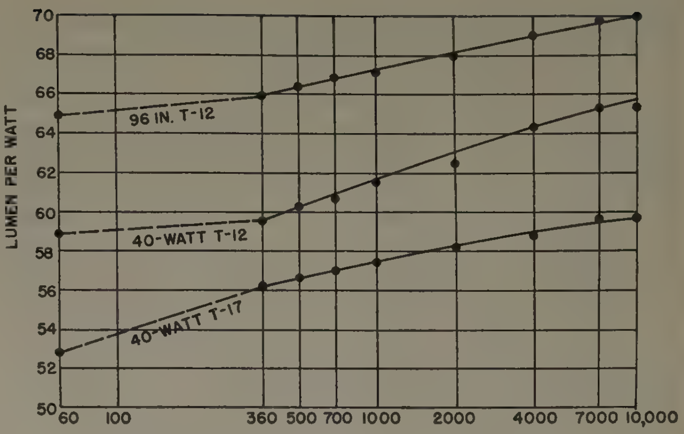

Figure 3. **With an increase in frequency the amount of emitted light per watt input is increased in fluorescent lamps up to 10,000 cps at which point plateaus are reached**

Radio-Frequency Interference. Because of the poor waveforms obtained in many 60-cycle circuits, fluorescent lamps produce annoying interference with radio reception. A Fourier analysis of such a waveform shows that it contains strong components in the radio-frequency range. It is these components which are believed[3] to be responsible for the static picked up on radio sets when fluorescent lamps are operated.

As shown in Figure 2, the waveform at frequencies above 60 cps becomes an excellent approximation to a pure sine wave. A Fourier analysis consists of one term. If the frequency at which the lamps are operated is at least 3,000 cps and is not in the broadcast band, there will be no appreciable radio-frequency interference.

Flicker and Stroboscopic Effect. The flicker of the light from a fluorescent lamp depends on the frequency at which it is operated, the waveform, and the decay rate of the phosphor. As most fluorescent lamps now manufactured use long-decay phosphors, the flicker of the light radiated from the mercury column is smoothed out before the light escapes from the tube.

Hecht and Shlaer[4] showed critical flicker frequencies up to 63 cps. Thus, the light from the central region of a fluorescent lamp, which flickers at double the operating frequency, will be fused satisfactorily even for 60-cycle operation. A component from the ends of the tubes[5] flickers at 60 cps and may cause annoyance if the lamps are not shielded from direct view. But at any frequency above 60 cps, no flicker is detectable by direct observation of the fluorescent lamps.

Stroboscopic effect is quite another matter. A light source which operates well above the flicker fusion frequency may do peculiar things to objects in motion. Rotating machinery may appear to stand still when it is in motion, to go backwards when it actually is going forwards, or to rotate at an entirely deceptive speed. Under incandescent lighting, where the per cent flicker varies[5] (at 60 cps) from 5 per cent for a 100-watt lamp to 12 per cent for a 40-watt lamp, difficulty with stroboscopic effect is not experienced. The phosphors now being used on fluorescent lamps have a sufficiently slow decay rate to reduce the flicker[5] from 100 per cent to 27 per cent for the warm white,

Table I. Lumen Output of Fluorescent Lamps as a Function of Frequency (at Rated Power Input)

Frequency (Cps)	Lumens/Watt Expressed as Percentage of 60-Cps Values 40-Watt T-12	 40-Watt T-17	 96-Inch T-12
60	100	100	100
360	101	107	102
1,000	104	109	103
3,000	108	110	106
10,000	111	113	108

Table II. Design Data for High-Voltage Group Operation Circuit

	Type of Lamp 40-Watt T-12	 40-Watt T-17	 96-Inch T-12
Rated lamp current (ampere)	0.430	0.425	0.425
Rated lamp voltage	99	103	190
Equivalent lamp resistance (ohms)	230	242	447
Recommended minimum starting voltage	385	385	625
C (microfarad) at 3,000 cps	0.0611	0.0607	0.0379
L (henry) at 3,000 cps	$\frac{4.93\times10^{-2}}{n}$	$\frac{4.99\times10^{-2}}{n}$	$\frac{8.18\times10^{-2}}{n}$

n = number of lamps in one group.

44 per cent for the cool white, and 58 per cent for the daylight lamp operated singly on an inductive ballast at 60 cps. As the phosphor decay is exponential in character, increase in frequency swiftly will eliminate the flicker in the light from fluorescent lamps. Even at the lowest frequency that has been considered[6,7] for "high-frequency" operation[*] of fluorescent lamps, namely 360 cps, the problems of flicker and stroboscopic effect simply do not exist.

Acoustic Consideration. The hum from 60-cycle ballasts is a familar accompaniment to fluorescent lighting. Such noise results primarily from vibration of magnetic core laminations. The frequency of the mechanical vibration and of the sound radiated is twice the frequency of the applied voltage.

As it is possible to replace most of the inductors required at 60 cps by capacitors at 360 cps or above, the new high-frequency circuits will tend to contain a smaller number of noisy elements than are ordinarily used at present. Also, by using the Group Operation Principle it is possible to place all inductors and transformers in wall boxes which can be acoustically treated. Thus, hanging luminaires no longer can act as sounding boards to amplify ballast noises.

Nevertheless, hum from the auxiliaries is always present to some degree and it would be advantageous to choose the frequency of operation so that such noise falls in the least objectionable frequency range. According to Knudson and Harris[8] minimum masking effect will occur if the frequency is near the top of the audible spectrum. "Low-pitched tones. . . .produce a marked masking effect upon high-pitched tones, whereas high-pitched tones produce only little masking effect upon low-pitched tones." The frequency range for ordinary speech runs from about 100 to 7,000 cps, while the ear[8] is most sensitive at about 3,000 cps. Therefore the most objectionable frequencies of ballast noise are in the range 100 to 3,000 cps and the least objectionable near 7,000 cps or above. A frequency of 60 cps gives noise at 120 cps and is particularly effective in masking the entire range of frequencies used in speech. A circuit frequency of 1,000 cps gives 2,000 cps noise which is near the peak of the aural sensitivity curve. With a 3,000-cps generator, the noise occurs at 6,000 cps in the upper part of the range of frequencies used in speech. Masking of speech is negligible. Also, sound at this frequency may be inaudible to a large fraction of adults whose ability to hear high frequencies has decreased. Thus, for minimum acoustical interference from vibrations in the auxiliary equipment a frequency of at least 3,000 cps should be used.

Weight of Auxiliary Equipment. While the electrical characteristics of a fluorescent lamp may vary somewhat with frequency, the reactance required for current limitation is essentially constant. But since the reactance is $X_L = 2\pi fL$ or $X_C = 1/2\pi fC$, the magnitude of the inductance L or capacitance C varies inversely as the frequency. For a given design of reactor the required weight is therefore approximately inversely proportional to the frequency. If the same circuit is used, a change from 60 to 3,000 cps might be expected to produce a reduction in weight of auxiliary equipment by a factor of 50! Variations in design, as frequency is changed, will produce deviations from this simple rule but will not alter the fact that increase in frequency will produce marked reduction in the size and weight of current-limiting and starting devices.

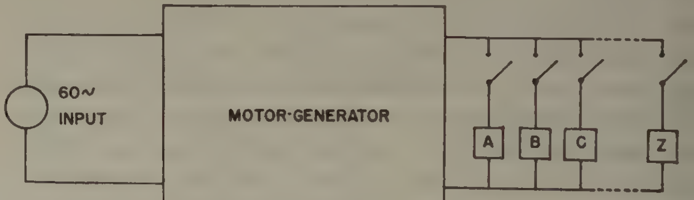

Figure 4. **A, B, C, . . ., Z represent groups of lamps, each controlled by a single switch and connected as shown in Figure 5 or Figure 6**

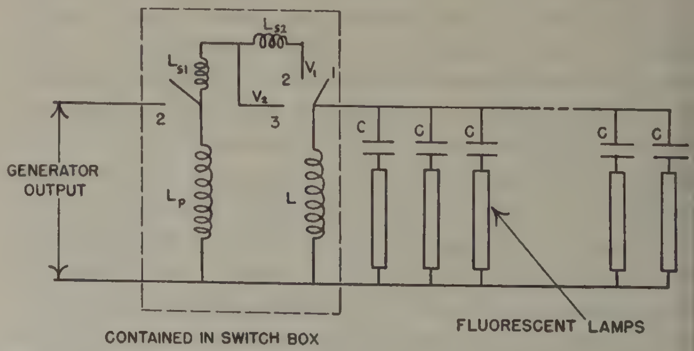

Figure 5. **High-voltage group operation circuit**

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[*] "Investigation of Fluorescent Lamps at Frequencies Above 60 Cycles," Kuo-Shu Chao. Master of Science Thesis, Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass., 1949.

"Fluctuations in Color and Helios of a Fluorescent Lamp," J. A. Losh. Bachelor of Science Thesis, General Engineering, Massachusetts Institute of Technology, Cambridge, Mass., 1950.

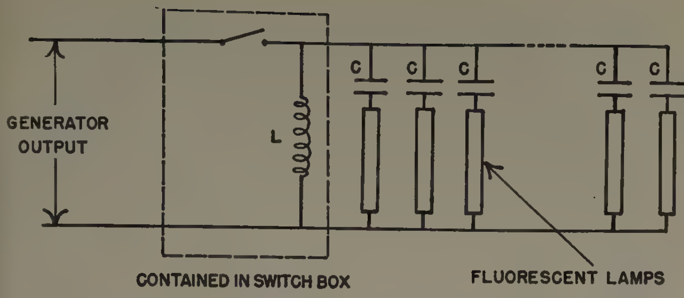

Figure 6. Low-voltage group operation circuit

Transmission. A question might be raised as to the distances over which higher frequencies can be transmitted. Consider a quarter-wavelength criterion as a basis of comparison:

Frequency (Cps)	1/4 Wavelength (Miles)
60	778
300	155
1,000	47
3,000	16
10,000	5

It can be concluded that even at 10,000 cps no difficulty with fluctuating line voltage will be experienced up to distances of 5 miles. If greater transmission distances are desired, they can be used; judiciously placed compensating capacitors are the only additional equipment that is required.

CIRCUITS

In the most common case, in which power must be obtained from a 60-cycle supply, the circuit shown in Figure 4 can be used. A motor-generator set converts to a higher frequency. The Group Operation Principle is employed. In most applications entire rooms are to be illuminated; not one or two fluorescent lamps, but the entire group controlled by a single wall switch are to be operated. Therefore it is advantageous to design the auxiliary circuit for an entire group of lamps and to incorporate as much as possible of the circuit into the wall switch casing.

In d-c districts, fluorescent-lamp operation is not economical without use of a motor-generator set. The frequency should be chosen for optimum operation of fluorescent lamps and should be not 60 but 3,000 to 10,000 cps. If a large factory or office building is to be supplied by its own generating station, the generators can be designed for a suitable frequency with little added expense.

For the group operation of fluorescent lamps two systems have been designed and tested in collaboration with Professor J. R. Harrison and R. A. Coradeschi at 60, 360, and 3,000 cps. Figure 5 shows the system to be used when the high-frequency supply is designed to give the starting voltage required by the lamps. The capacitors *C* limit the lamp current to rated value, while the inductor *L* provides unity power factor at each switch. Some typical design data for the high-voltage group operation circuit of Figure 5 are given in Table II.

In some cases, it may be inadvisable to use the full starting voltage of the lamps between line wires of the distribution system. Then a different circuit, Figure 6, may be employed. The switch box contains an autotransformer, an inductor, and a 3-position switch. In the off position, *1*, the autotransformer is not connected to the lines. The switch is designed so that it moves to position *2* for a predetermined time and then automatically continues to position *3* where it remains during operation. In position *2*, the starting voltage V_1 is supplied to the lamps. An inductor is placed in parallel with the group of lamps to provide unity power factor. The transient is easily adjusted to the optimum for the lamp by design of L_{S2} and by the timing of the switch. The voltage V_2 supplied for steady-state operation of the lamps can be much less than V_1. The capacitors *C* must provide a reactance of the

Table III. Data for Calculating Cost

Quantity	40-Watt T-12 Lamp 3,000 Cps	 60 Cps	40-Watt T-17 Lamp 3,000 Cps	 60 Cps	96-Inch T-12 Lamp 3,000 Cps	 60 Cps
F (lumen)	2,540	2,350	2,580	2,350	5,240	4,950
k_a	0.10	0.10	0.10	0.10	0.10	0.10
Cost of luminaire per lamp	686¢	686¢	936¢	936¢	1547¢	1547¢
Cost of ballast per lamp	95¢	314¢	97¢	314¢	95¢	453¢
Cost of motor-generator per lamp at $100/kva	403¢		423¢		764¢	
C	1,184¢	1,000¢	1,456¢	1,250¢	2,406¢	2,000¢
t (hours per year)	2,500	2,500	2,500	2,500	2,500	2,500
b (¢/kwh)	1.5	1.5	1.5	1.5	1.5	1.5
Power to lamp (watt)	39	39	41	41	74	74
Power to ballast per lamp (watt)	1.25	11	1.31	11	1.82	16
Power to motor-generator per lamp (watt)	7.65		7.62		14.52	
P (watt)	48	50	50	52	90	90
c (cents)	92	92	208	208	280	280
L (hour)	2,800	2,500	2,230	2,000	2,800	2,500

Table IV. Cost Per Million Lumen-Hours

	40-Watt T-12 Lamp Cost (Cents)	 Saving (Per Cent)	40-Watt T-17 Lamp Cost (Cents)	 Saving (Per Cent)	96-Inch T-12 Lamp Cost (Cents)	 Saving (Per Cent)
60 cps Conventional instant start ballast	64.7	0	98.8	0	66.0	0
3,000 cps Circuit of Figure 5 with motor-generator set costing $100/-kva	60.0	7.3	88.0	11	63.1	4.4
3,000 cps Circuit of Figure 5 with motor-generator set costing $25/-kva	55.3	15	83.0	16	58.8	12
3,000 cps Circuit of Figure 5 without motor-generator set	53.7	17	81.3	18	57.4	13

Table V. Weight of Auxiliary Equipment Per Lamp

	40-Watt T-12 Lamp 3,000 Cps	 60 Cps	40-Watt T-17 Lamp 3,000 Cps	 60 Cps	96-Inch T-12 Lamp 3,000 Cps	 60 Cps
Ballast	0.125 lb.	4.13	0.119	4.13	0.173	6.50
Motor-generator set	2.28		2.40		4.34	
Total	2.41	4.13	2.52	4.13	4.51	6.50

same order of magnitude as the equivalent lamp resistance, if stability is to be attained. V_1 is adjusted to supply rated lamp current. The chief disadvantage of this circuit is that a complex switch must be used. Its advantage is the flexibility with which the transient can be controlled and the comparatively small power losses (as compared with conventional 60-cycle ballasts).

The circuits of Figures 5 and 6 are especially adapted to high-frequency operation. However, if the series capacitors are replaced by series inductors and the power factor correcting inductors are replaced by capacitors, these group operation circuits also have application at 60 cps. Losses are reduced to about 10 per cent of those obtained with conventional ballasts and weight to about 20 per cent of the weight of ordinary 60-cycle ballasts, for the circuit of Figure 6, and even more radically for the high-voltage circuit of Figure 5. It would seem that such group operation circuits would find extensive application in lighting practice.

COST

After having considered the many advantages of employing a higher frequency such as 3,000 cps, the final question is, "How do the costs compare with those of conventional 60-cycle circuits?" The high-frequency system has the economic advantages of higher lumen output, longer lamp life, and replacement of the conventional bulky and expensive ballast by miniature, inexpensive capacitors and inductors. It has the disadvantage that a motor-generator set must be purchased, unless it is possible to build a generating station for the desired frequency.

A valid way of comparing different systems is to determine the cost per million lumen-hours. It is calculated according to the equation[9]

$$y=\frac{10^6}{F}\left[\frac{k_aC}{t}+\frac{bP}{1000}+\frac{c}{L}\right] \text{ cents/million lumen-hour}$$

where F = pharos (lumen) from one lamp; k_a = factor depending on interest, depreciation, and maintenance; C = initial cost of lighting installation per lamp(cents); t = hours operation per year; b = cost of electric energy (cents per kilowatt-hour); P = power input for one lamp (watt); c = cost of renewal lamp (cents); L = life of lamp (hour).

Typical conservative data for three important types of fluorescent lamps are given in Table III. The results are summarized in Table IV.

It will be noticed that, even if the motor-generator set costs as much as $100 per kilovolt-ampere, the 3,000-cycle system never exceeds the cost of the conventional 60-cycle system. If the motor-generator set can be eliminated entirely, as in a large factory that generates its own electricity, the savings are between 13 and 18 per cent of the cost of a conventional lighting system. A reasonable estimate of quantity costs of such frequency conversion equipment is $25 per kilovolt-ampere. For this cost, the financial savings are 12 to 16 per cent.

According to the data shown in Table IV, the costs of operating either the 40-watt *T-12* or the 96-inch *T-12* lamps are roughly comparable. The cost of operating the "low-brightness" *T-17* lamp is 50 per cent more. Thus, it is clear that the use of bare, low-brightness lamps to save purchasing a quality fixture is distinctly false economy.

Perhaps one of the greatest advantages of the 3,000-cps circuit is that auxiliary equipment virtually is eliminated from the luminaire (Table V). Only one miniature capacitor (about 0.05 microfarad for the lamps considered) must be placed in the luminaire in series with each lamp. A small inductor for power-factor correction fits into the switch box. The combined weight of capacitors and inductors (per lamp) is about 3 per cent of the weight of the conventional ballasts. Even if a motor-generator set must be used, the over-all savings on weight of auxiliary remain high, running between 30 and 42 per cent for the lamps considered here.

CONCLUSIONS

The foregoing sections have shown that optimum operation of fluorescent lamps is obtained at frequencies in the range of 3,000 to 10,000 cps. If the lamps are operated at 3,000 cps, for example, the system is both practical and economic. The following advantages are obtained: (1) Linear volt-ampere characteristic for fluorescent lamps; (2) Sinusoidal waveshape; (3) Larger lumen output at rated power input (between 6 and 15 per cent increase); (4) Increased lamp life (12 per cent or more); (5) No visible flicker; (6) No stroboscopic effect; (7) Bulky, heavy ballast eliminated from luminaire; (8) Unity power factor load; (9) Low ballast losses (savings up to 28 per cent with motor-generator losses included and nearly 90 per cent if power is generated at 3,000 cps); (10) Quick starting; (11) No audible ballast hum; (12) No radio-frequency interference; (13) Weight of metal required for lamp auxiliaries reduced (savings of 30 to 42 per cent if motor-generator set is used and 97 per cent if power can be generated at 3,000 cps); (14) Over-all cost of lighting system reduced (savings of 4 to 16 per cent with price of motor-generator included and 13 to 18 per cent if power is generated at 3,000 cps).

The engineer who is designing any large lighting system should give careful consideration to the advisability of shifting from 60 to at least 3,000 cps.

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Modern Forced-Air Cooling of Power Transformers

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The available types of forced-air fans and control methods, their application to power transformers, and the advantages of each type for specific installations are discussed.

FORCED-AIR-COOLING fans have been used for many years to obtain increased ratings on electric apparatus. The large liquid-filled power transformer is one of the most natural applications for this type of cooling of any of the electric devices. The radiators which are supplied on the transformer to obtain the self-cooled rating offer large surface areas which are cooled for the most part by convection. The use of forced-air fans to accelerate the convection process results in an increase in efficiency of this surface as much as 200 per cent, see Figure 1.

To accelerate convection it is necessary to supply relatively large volumes of cool air at moderate velocities over large surfaces. A natural wind with a velocity of 15 to 20 miles per hour will produce this result. It also can be produced by locating several individual fans at advantageous places at or near the cooling surface of the transformer. Various methods of applying fans to power transformers will be described.

With the increase in size of power transformers, this type of supplementary cooling becomes more and more valuable. The radiators that are necessary to self-cool a large power transformer often require more space than the transformer itself. This space can be materially reduced by the use of forced-air fans. It would be impractical and uneconomical to build units above 150,000 kva (except water-cooled) without the use of forced-air fans. On these large units, fans, in conjunction with oil-pumping equipment, permit the basic transformer parts to be kept within manufacturing, shipping, and field-handling limitations. At present about 75 per cent of all power transformers 10,000 kva and above are equipped with fans at the factory, and a great many more fans are applied in the field.

APPLICATION

OPERATORS CAN USE forced-air cooling in several ways to obtain the best advantage. Fans can be run continuously or intermittently, depending on various factors which are peculiar to each individual installation.

One practical method of applying forced-air cooling is to build the transformer with enough radiators to self-cool the average load, and provide fans to take care of peak loads and unexpected overloads. This practice combines the complete reliability of self-cooling with the inexpensive means of obtaining additional capacity by the use of fans. Another advantage of this arrangement is that the fan noise is only present during periods of peak load, which almost invariably concur with periods of high ambient noise.

Continuous fan operation also offers certain advantages. Where the transformer is supplying a steady load and where fan noise is of little consequence, continuous operation of fans will permit the purchase of a smaller transformer. Control problems are eliminated when fans are operated continuously.

Even in cases where the load cycle would permit shutting off the fans at certain intervals, it sometimes may be desirable to continue their operation. The lower loss which results from the lower copper temperature thus obtained will usually more than take care of the additional power required by the fans. Thus, an over-all decrease in total loss is obtained. In addition to the lower loss, a theoretical increase in transformer life will result from the lower temperatures obtained by running the fans.

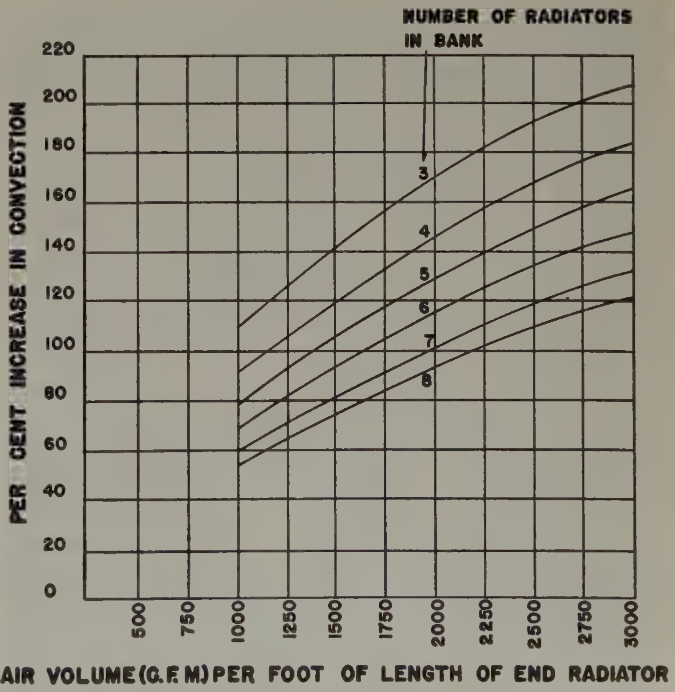

Figure 1. Curve showing per-cent increase in convection obtained by mounting forced-air-cooling fans on the end of a bank of flat-fin radiators

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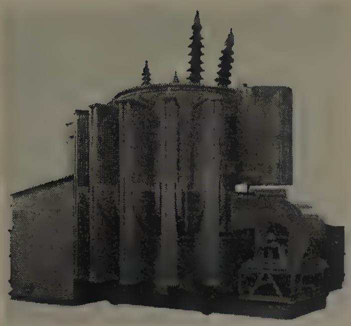


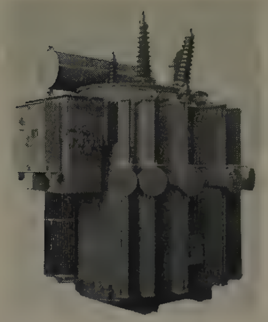


Figure 2 (left). Early method of forced-air cooling, using a central blower supplying air to the coolers through metal ducts. Figure 3 (right). Forced-air cooling obtained from individual fan housings mounted on the outer edge of each cooler

Usual designs of large forced-air-cooled power transformers allow for a $33^{1}/_{3}$-per-cent increase in load when fans are running. Where 67-per-cent increase in capacity is required, it is more practical to use a combination of fans and oil-circulating pumps. The increase in oil velocity made possible by the pumps enables the heat to be carried away more rapidly than with fans alone, and results in small differences between top and bottom oil temperatures. The lowered temperature of the top oil results in lower winding hot spots.

Most self-cooled transformers can be equipped with fans in the field to obtain some amount of increased capacity, depending on the original design and its present condition. Where the unit was not originally designed for future application of fans, the internal parts such as leads, tap changers, and bushings may be the limiting factor. One of the following methods can be used to apply fans to field units.

Early attempts at forced-air cooling of oil-insulated transformers followed the existing practices used in air-insulated types. A central fan of the ventilating type was encased in a metal housing and by means of metal ducts blew air on the radiator cooling surfaces. An example of this type is shown in Figure 2. While this method gave adequate cooling, there were several factors that led to its abandonment. Valuable floor space was required for the fan housing, and the duct work was difficult to design, manufacture, and install. Time was required to lay out and fit the metal ducts on each particular application. The motor and fan had to be specially designed and in general the sound level of such installations was quite high. Continuing increase in transformer size made the duct work increasingly intricate, impractical, and expensive.

The individual fan housing and duct was developed, as shown in Figure 3, to overcome the preceding objections. The combination fan housing and air duct was made to slip over the end of each individual cooler, and to blow the air up along both sides of the cooler. This arrangement made it possible to use standard assemblies and fans, and made it unnecessary to design an air duct system for each particular job. Still there were some difficulties that this scheme did not solve such as the need for a large number of fans and the installation problem. Also a slight increase in floor space still was required.

The introduction of the flat-fin-type radiator in 1930, permitted the next practical improvement in the method of applying forced-air-cooling fans. With this new radiator, flat-fin cooling elements were used instead of round tubes. Any required number of these radiators can be mounted on the wall of the transformer case. When mounted side by side in this manner, a series of continuous ducts is formed through which air can be forced very easily and efficiently by means of one or more fans on the end of the bank. See Figure 4. By this arrangement the number of fans required is radically reduced, since it is no longer necessary to mount a fan on each radiator. At the same time the mounting is made simpler, maintenance and replacement becomes a relatively easy matter, and no additional floor space is required.

On smaller transformers with tubular coolers the same fan is used under the tubes as shown in Figure 5, or mounted on the side of the tubes at an angle. The former method is used when providing new transformers with fans at the factory, and requires space under the cooler to mount the fan assembly. Because of this space requirement some field jobs may not be adaptable to the under-tube type of mounting. For those cases, the side-of-tube angle mounting can be used.

The same type of fan used with a forced-oil-to-air heat exchanger is shown in Figure 6. In this application the fan is enclosed in a sheet-metal housing and arranged so as to draw air through the tubes and away from the transformer. In this manner recirculation of air is minimized.

Another practical application of the forced-air fan is the separately mounted type shown in Figure 7. If the floor space is available, this type can be made very effective by proper location of the fans. The best cooling obtainable with this fan is an arrangement that creates a vortex of air, with the cool air being brought in at ground level, circulated around the coolers, and the warm air pushed upward away from the transformer.

The choice of the particular type of fan cooling depends on many factors and varies with the installation. Space, load, sound ambient, as well as economic considerations, are all involved, and the proper weighing of all these factors is necessary to obtain the most suitable application.

FAN REQUIREMENTS

There are several attributes of a good forced-air-cooling fan for use with transformers. For the most part they are factors which are interrelated, so that a satisfactory compromise must be made on some characteristics to obtain the desired over-all performance.

1. *Air Delivery.* It is obviously desirable to have a fan which delivers large quantities of air so that the total number of fans required for a particular application can be kept to a reasonable figure. The fan size and speed and the blade configuration and pitch all can be varied to give more air. These factors, however, also contribute to the sound level of the fan, which in some instances is the characteristic which imposes the limit on transformer performance. Modern forced-air-cooling fans deliver air volumes of 3,000 to 7,500 cubic feet per minute, with air velocities of at least 1,000 feet per minute leaving the

fan. Some large power transformers require as much as 300,000 cubic feet per minute of air at their forced-air rating.

The air volume versus sound level relationship for typical forced-air-cooling fans is given in Table I.

Table I. Performance of Typical Forced-Air-Cooling Fans on Power Transformers

Fan	Fan Diameter (Inches)	Air Volume* Per Cent of Fan A	Fan Noise† Decibels (40)	Motor Input	
				Volt-Amperes	Watts
A	26	100	65.5	335	227
B	26	81	58.3	286	204
C	26	61	54.6	246	148
D	26	58	51.3	139	62
E	26	50	48.3	156	64
F	18	44	56.2	234	134

* Measured with anemometer per preliminary National Electrical Manufacturers Association (NEMA) Standards *1-FM*.

† Measured on 6-foot radius from fan per NEMA Standards *TR-130*.

2. *Sound Level.* The sound level of a fan must be kept low enough so that it does not penalize the transformer design. If fan noise is high, it is necessary to design the transformer to a lower than normal sound level. National Electrical Manufacturers Association (NEMA) standards permit in general a 3-decibel increase in total transformer sound level when forced-air fans are applied to a self-cooled transformer. Since the addition of two equal sound levels results in approximately a 3-decibel increase, this means that the sound level of the required number of fans approximately should equal that of the transformer alone.

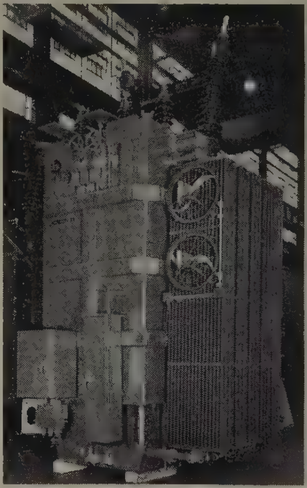
3. *Fan Speed.* The other factor which is related closely to fan noise and air volume is the fan speed. For many years standard motors having a speed of 1,725 rpm have been used and are today suitable for most applications. In some special cases where fan noise becomes excessive due to the large number of fans, or in situations where extra low sound levels are required, motors running at 1,140 rpm are being used. In a few very special applications the speed has been reduced further to 860 rpm. It is to be noted, however, that a mere change in speed is not sufficient for best fan performance, since fan blades are designed for a certain optimum speed and lose much of their efficiency at a lower speed. A complete redesign of the blade is necessary for best efficiency at slow speeds.

It can be stated in general terms that for two fans delivering equal air volumes, the one having the lower tip speed will have the lower sound level. There is, however, a limit to the amount of speed reduction that can be tolerated due to the need for sufficient air velocity to obtain adequate cooling efficiency.

4. *Vibration Damping.* A rotating fan cannot be expected to run free of vibration even though it is statically balanced. Certain forces of unbalance are created by the motor rotation, air pressure on the blade, and various other factors thus leading to vibrations. While usually of a minor nature, they can be amplified many times by sympathetically induced vibrations in surrounding mediums.

The effect of fan vibration on radiators can be minimized either by spring mounting or by solid mounting. The use of rubber or neoprene shock mounts can be effective, but considerations of cost, expected life, and sag make it less attractive than the extremely rigid structure shown in Figure 8. The angle ring which is used as a shroud is the foundation of a strong steel combination guard and motor mount which has proved very effective in reducing vibration effects.

Another medium that can transmit the fan vibrations is the conduit formerly used to make electric connections between fans. The use of flexible neoprene connecting cable between the fan motor and the supply conduit has eliminated this effect.



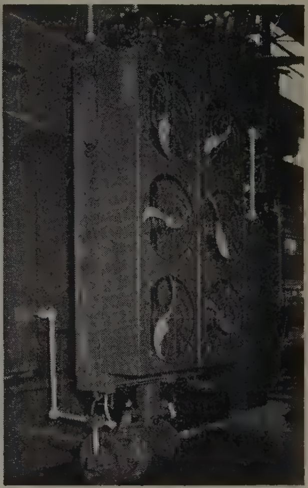


Figure 4 (left). Modern method of forced-air cooling, using a small number of fans on the end of a bank of flat-fin radiators. Figure 6 (right). Forced-oil-to-air heat exchanger mounted on a transformer

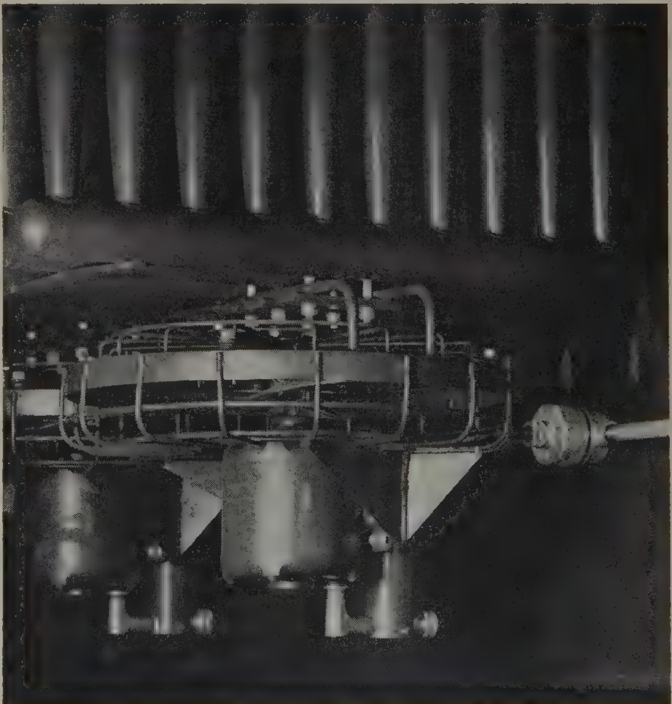
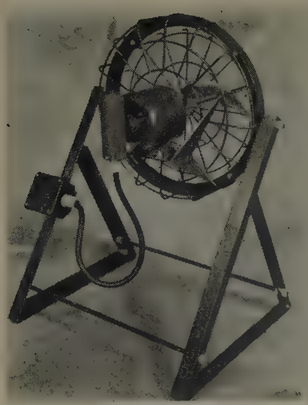


Figure 5. Forced-air-cooling fans mounted under a row of tubular coolers



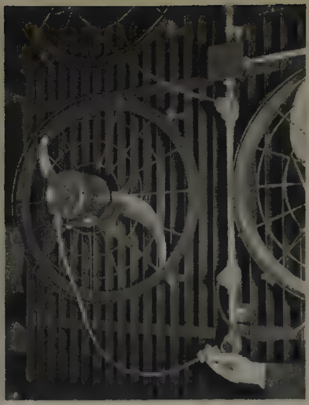


Figure 7 (left). Portable-type forced-air-cooling fan. Figure 8 (right). Close-up of modern forced-air-cooling fan mounted on the end of a bank of tandem radiators

5. *Weatherproof Construction.* Until the introduction of the outdoor-type motor in the late 1930's it had been necessary to go to elaborate means of providing a weather shield over the motor. For periodic greasing a long extension tube was added to the grease fitting to make it accessible from the outside of the weather shield. Modern outdoor-type fan motors have eliminated these gadgets and have given very satisfactory performance in all kinds of weather. They are simple to mount and easy to install. They require very little attention other than an occasional inspection, greasing every 1 to 2 years, and painting whenever the transformer is painted. In a few cases where water has gotten inside, the motor has been drained out, dried, and put back into service.

It also is necessary that the fan blade be made of weatherproof material. A cast aluminum-alloy type of blade has been used with very good results in regard to corrosion and exposure. Experience during the war years with wood and plastic blades proved far from satisfactory. It is possible that some of the new plastics will produce a blade that is suitable for outdoor service, but none has been available thus far.

An additional advantage of the cast-aluminum blade is in regard to the sound level. The audible sound from the cast blade is duller and less obnoxious than the sound produced by the sheet-metal type of fan blade.

6. *Motor Protection.* Built-in Thermoguards recently have been added to fan motors to provide overload protection. This further simplifies the air-blast fan application by eliminating the need for fuses and fuse boxes. It no longer is necessary to replace fuses when fans have been stalled due to snow, ice, or any other reason.

The Thermoguard is a temperature-actuated snap switch which opens when dangerous temperatures are reached and closes when the motor has cooled sufficiently to be put back on the line. Placed in one line of a single-phase motor and in two lines of a 3-phase motor, it provides complete protection against overloads, locked rotor, and in the case of 3-phase motors against single-phase burnouts. In a laboratory locked-rotor test, a total of 32,000 Thermoguard operations were observed with no damage to motor or Thermoguard.

7. *Reliable Starting.* Sufficient starting torque is necessary for a good forced-air-cooling fan. This is no problem on the 3-phase motor, and with proper selection of capacitor, the single-phase motor can be made adequate. The use of internal switches has proved inferior to the single-phase capacitor-start capacitor-run type of motor.

The question of motor reversal often has been discussed in regard to forced-air fans. In cases where a natural breeze has caused the fans to be turning in the direction opposite to the normal rotation, it has been questioned whether the fan will reverse and run in the right direction when the fan is energized. Three-phase motors will do so, but it is quite possible for a single-phase fan to continue to run in the wrong direction, with a subsequent loss in cooling efficiency. Since reverse rotation in no way will cause damage to the motor, this operation is entirely satisfactory, for the cooling derived from the natural breeze should more than compensate for the loss in fan efficiency due to the reversal.

Due to the foregoing factors, the 3-phase motor offers more attractive over-all advantages than the single phase for transformer cooling fans. More starting torque, complete reversal, and elimination of the capacitor all favor the use of the 3-phase motor.

8. *Unit-Type Assembly.* A unit type of fan assembly is much to be desired, especially in field maintenance or field application work. The fan assembly shown in Figure 8 can be electrically unplugged and mechanically removed without de-energizing the fan circuit, resulting in a great savings in field replacement. It also makes it possible to carry one or a very few spare fans which can be installed immediately in place of a removed fan.

CONTROL

Control of forced-air fans can be manual or automatic. Automatic starting can be actuated by hot-oil temperature devices, hot-spot temperature devices, or thermal-overload relays.

Manual control of fans is the simplest method to supply on new transformers, and obviously offers the simplest answer to field installations on transformers where no provision has been made for automatic control. In attended stations, the operation of the forced-air fans can be co-ordinated by the operator with readings of transformer load, current, temperature, or any combination of these conditions. One advantage of this type of control lies in the ability of a human being to make certain decisions that are beyond the scope of a simple automatic device. Manual control, with its lack of maintenance problems, is very attractive to many operators.

Automatic control by hot-oil temperature is the next in line as regards simplicity. A thermometer or thermostat, with its bulb immersed in the transformer top oil, can be used to actuate the fan starting switch at a predetermined temperature. This presupposes that the top oil temperature variations are a suitable measure of the transformer temperature, which is the case in generating station transformers or other applications where rapid load variations are very rare.

Where operating conditions permit rapid load changes, the relative time constants of the transformer copper and oil make it possible for the oil temperature to lag too far behind the winding temperature to be of practical value in controlling fan operation. For this type of condition a thermal relay, type *TRO*,[1] is available. The *TRO* relay is a device which closely follows the ability of the transformer to carry loads in accordance with existing American Standard Association Guides.[2] In addition to starting the fans, the *TRO* relay is used to indicate the approach of dangerous winding temperatures, and finally to sound an alarm or trip the circuit breaker if the increase in temperature rise persists. This relay also is provided with an indicating dial to give the operator a continuous reading of the thermal load on the transformer.

Another device that sometimes is used to start fan operation is the hot-spot thermometer. This device is essentially a thermometer or thermostat with the bulb encased in a heating coil and placed in the top oil. A current proportional to the load is circulated through the heating coil by means of a current transformer. In the calibration of this device an arbitrary hot-spot allowance is added to the copper-to-oil difference to enable the bulb temperature to simulate the winding hot spot rather than the winding temperature.

CONCLUSIONS

The foregoing discussion outlines the types of forced-air fans and control methods that are available, and their application to power transformers. Each of these types has its value for particular installations. It is hoped that a better understanding of the available methods of forced-air cooling will result. In this manner, the operator can determine the best application to meet his requirements, and the manufacturer can be sure of supplying the type of equipment that the industry needs.

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Noise and Crosstalk Control on N1 Carrier Systems

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The most important sources of noise—system noise, secondary induction from telephone plant and external sources, and nonsoldered cable pair joints—are discussed together with the methods of alleviating the trouble. Although control of crosstalk had been facilitated by the N1 system design, it still has to be dealt with in connection with transverse crosstalk, crosstalk in lateral cables, and interaction crosstalk at repeaters and at terminals.

The 12-channel *N1*-carrier system is designed primarily for short- and medium-haul service and to make use of existing and new cable plant with a minimum of special treatment. As compared to other types of carriers, the lower transmission levels of the *N1* system tend to make it more susceptive to interference from external sources. The use of higher line frequencies with the corresponding decrease in coupling loss between line conductors tends to increase the amount of crosstalk between carrier systems. While the technical features of the *N1* system already have been described[1] it may be well to review some of the characteristics that are of interest in connection with the control of noise and crosstalk on message circuits. These include:

1. Transmission of both sidebands and the carrier.
2. A compandor per channel. At the transmitting end, a compressor raises the average talker volume by about 10 decibels and reduces by one-half the normal range of talker volumes. At the receiving end, a complementary expandor restores the talker volumes to their normal range.
3. Transmission in the two directions in different frequency ranges on separate pairs in the same cable. Low group frequency range, 44–140 kc; high group range, 164–260 kc; frequency inversion at each repeater by modulating the signal with a 304-kc carrier.
4. In each repeater section the carriers at the high-frequency end of the band are transmitted at higher level than those at the low-frequency end. Due to the increase in

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Full text of paper 53-226, "The Control of Noise and Crosstalk on *N1* Carrier Systems," recommended by the AIEE Committee on Wire Communications Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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The successful application of the *N1* carrier system has been made possible by the combined efforts of many persons and it is not feasible to mention them individually. However, the authors wish to acknowledge the work of S. E. Church, S. G. Hale, H. A. Stone, Jr., R. S. Tucker, and M. A. Weaver, all of Bell Telephone Laboratories, Inc., whose contributions to the solution of noise and crosstalk problems have been very valuable.

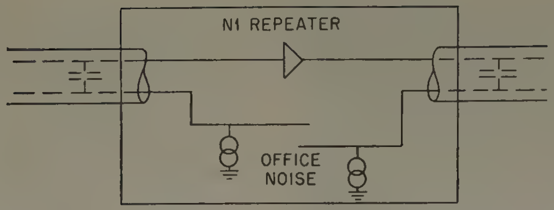

Figure 1. **Secondary induction from telephone plant**

attenuation with frequency, the relative levels at the receiving end are reversed.

CONTROL OF NOISE

Noise Objective. In general, the effective noise on an *N1* channel should not exceed 31 decibels adjusted referred to the zero level point. Under the Bell System General Toll Switching Plan for dial operation, the terminal net loss of a single circuit will vary from about 4.5 decibels up, depending upon the type of facility and the length of the circuit. If this objective is met, the maximum noise on even the lowest loss circuit will be about 5 decibels below the level at which the average subscriber would become conscious of its presence. Since the expandor in each *N1* channel terminal is designed to have a hangover time of about 40 milliseconds to avoid clipping the trailing ends of syllables, the noise present at the end of a high level signal is not as fully attenuated as during the silent interval. To achieve the equivalent of 31 decibels adjusted of noise on a noncompandored system, it has been found that the silent interval noise, as measured with a Bell System 2-type noise set, should not exceed 26 decibels adjusted.

Sources of Noise. The principal sources of noise encountered in the operation of *N1* systems and the measures taken to mitigate them are as follows:

1. *System Noise.* By design, the noise contributed by the repeaters and terminal equipment have been held to about −38 decibels adjusted of equivalent input noise for a 200-mile circuit. This noise consists of the usual "first circuit shsh" and interchannel modulation due to the nonlinearity of the modulators and demodulators. The noise from these sources is so low as to be masked by noise from other sources.

   The *N1* system uses "out of band" signaling employing both sidebands of a 3,700-cycle tone, transmitted 15 decibels below the carrier level. Since the channel filters do not entirely suppress these signaling tones, a small amount of noise leaks into the message channel. This noise is not generally significant since the signaling tone usually is removed during the talking period and is transmitted at a low level.

   A thermal noise generator is provided in the transmitting terminal of the *N1* system to furnish a controllable amount of steady hiss-type noise that may be used to mask low-level crosstalk or cross-modulation. Even with the maximum output of the generator, the thermal noise produces a negligible impairment to message circuit transmission while masking the crosstalk by about 5 decibels. So far no use has been made of this technique, but it is possible it will be employed as the number of *N1* systems in nonquadded cables is increased.

2. *Secondary Induction From Telephone Plant.* The operation of relays and switches in a telephone office puts noise voltages between the office wiring and ground. While the office wiring associated with the *N1* systems consists of shielded pairs, this noise is picked up by noncarrier wiring over which it travels longitudinally to pairs in the same cable sheath as the *N1* pairs. Due to the high longitudinal coupling between all pairs under the same sheath, noise voltages appear on the *N1* pairs, and depending upon their longitudinal-to-metallic balance, part of the noise appears in the metallic circuit. When installing *N1* carrier on existing cables, it generally is not feasible to improve the cable balance although it is possible to exclude from *N1* operation pairs having particularly poor balance. The path by which noise from internal sources enters the *N1* system is shown in Figure 1.

   Since little can be done to reduce the noise after it has entered the *N1* cable, it is desirable to suppress it before it reaches the carrier pairs. This might be done by introducing a high impedance into the longitudinal circuit of the noncarrier pairs without appreciably increasing their metallic circuit loss in the useful frequency range. With *K*-carrier systems this was accomplished by means of series retardation coils in the noncarrier circuits. This is expensive and a cheaper way of suppressing the noise of *N1* carrier systems still is being sought.

   One measure that has been used is to keep the carrier and noncarrier pairs in separate sheaths or shielded compartments for a limited distance from the office. As the length of the twin cable section is increased, the received signal level on the *N1* pairs at the point of exposure to the noise is increased and the noise itself is reduced, greatly improving the signal-to-noise ratio.

   Noise arising from the operation of telegraph equipment may be suppressed effectively at the source. In many cases the telegraph equipment already includes noise killers to control the noise in the audio-frequency range. These may be supplemented by suppression that is more effective at carrier frequencies. Not all types of telegraph systems cause serious interference. With metallic operation, the currents are so small as to create negligible disturbance. However, the large currents used with grounded simplex operation have proved bothersome. A simple filter consisting of a 0.5-microfarad capacitor connected between ground and the mid-point of the simplex deriving repeating coil will provide adequate suppression.

   One of the more commonly used measures to control

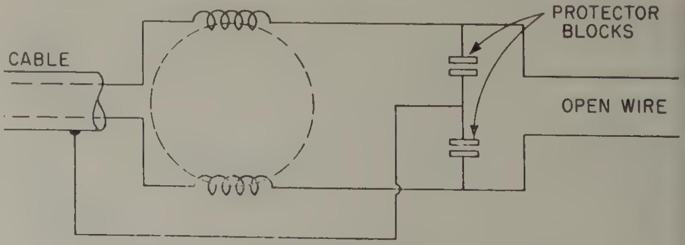

Figure 2. **Longitudinal retardation coil**

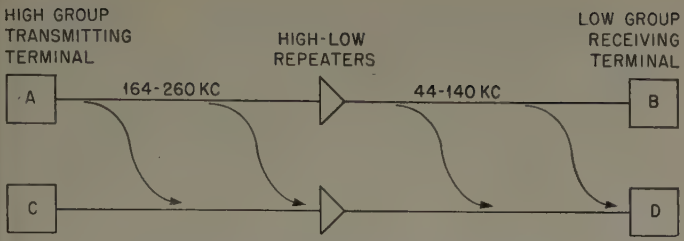
HIGH GROUP TRANSMITTING TERMINAL
HIGH-LOW REPEATERS
LOW GROUP RECEIVING TERMINAL
A
164-260 KC
44-140 KC
B
C
D

Figure 3. Transverse far-end crosstalk

dial office noise is to limit the length of the repeater section adjacent to the noise source and thus restrict the amount of noise gain. The amount of metallic noise on a cable pair at the main distributing frame in a dial office will vary widely but it has been found under typical conditions to be in the order of 100 decibels below one milliwatt in a 3-kc band in the *N1* frequency range. This compares with a sideband level at the input of a high-low repeater which may drop to 75 decibels below one milliwatt for a full 8-mile repeater section. At a high-low repeater the 304-kc carrier modulates noise components in the frequency range between 348 and 444 kc, the lower sideband of this modulation also falling within the 44–140-kc low-frequency group. This image frequency noise is excluded from low-high repeaters and low group receiving terminals by the low-pass filter, and is no problem at high group receiving terminals since the 304-kc group carrier is not present.

3. *Secondary Induction From External Sources.* The most important path for induction from sources external to the telephone plant is by secondary induction from noncarrier pairs in the *N1* cable which have extensions or taps to open-wire lines or to branch cables of short length connected to open wires or subscriber drops. Noise from atmospheric static or radio-frequency transmitters which is present on the open wire or drops is carried into the cable longitudinally where it appears as metallic noise on the *N1* pairs as previously discussed. Several different measures have been used to suppress this type of noise depending upon its magnitude, frequency, and nature.

Where suppression is desired over a wide range extending through the transmitted *N1* frequencies and the image frequency band, the most effective suppression is provided by longitudinal retardation coils which insert loss in the ground return circuit. Existing coils which were developed for use with the *K* and *J* carrier systems have been used to a limited extent but they are expensive and do not have adequate loss in the image band. New coils are under development and some prototypes have been tested with satisfactory results. It appears that they will afford about 25-decibel suppression throughout the entire *N1* transmitted and image frequency bands. In developing the new coil every effort is being made to keep its metallic circuit loss at a minimum. Figure 2 shows a longitudinal retardation coil connected at the junction of open wire and cable.

The experience with *N1* systems in the vicinity of Annapolis, Md., will serve to illustrate the application of this type of suppression. On many systems in this area, channels *3* and *7* were turned down because of interference from nearby radio transmitters. The noise was introduced into vulnerable points of the *N1* circuits by way of open-wire and drop-wire extensions of non-*N* cable pairs. The interference had been anticipated when engineering the carrier systems, and thus the two or three repeater sections nearest the radio transmitters were reduced in length to facilitate its suppression.

After placing the initial systems in service, experiments were begun to see what could be done to reduce to tolerable levels the noise on the affected channels. Between Annapolis and Hyattsville there were 354 different open-wire and drop-wire extensions of non-*N* pairs of which 106 required treatment to reduce acceptably the *N1* channel noise. The only major group of extensions requiring no suppression were in the $3^{1}/_{2}$-mile repeater section at the Annapolis end of the system. The suppression finally selected consisted of toroidal coils such as shown in Figure 2, wound so as to insert a relatively high impedance in the longitudinal circuit of the offending antenna-like pairs but not in the metallic circuits of these pairs. A design including high core loss gave a large resistive component to the impedance to aid in preventing resonance.

Table I shows how the noise in the affected channels was reduced by the installation of the 106 separate suppressors.

Table I. Reduction of Radio Interference Into N1 Systems

Channel	Noise at Zero Transmission Level—Decibels Adjusted: Without Suppression	Noise at Zero Transmission Level—Decibels Adjusted: With Suppression
Worst Number 3	67* 68†	27* 30†
Average Number 3	50* 52†	23* 27†
Worst Number 7	59* 49†	28* 25†
Average Number 7	50* 37†	22* 21†

* At Annapolis.

† At Hyattsville or Washington.

An interesting aspect of the tests was that subsequent removal of suppression from a single open-wire extension, 1,500 feet long, connected to the cable at a point about 12 miles from the radio transmitters raised the noise nearly to the level existing before any extensions were suppressed.

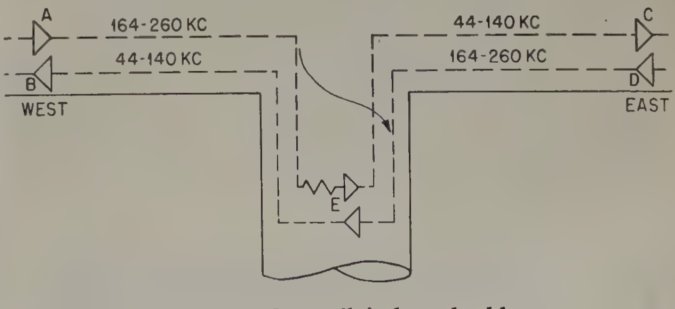

Figure 4. Crosstalk in lateral cables

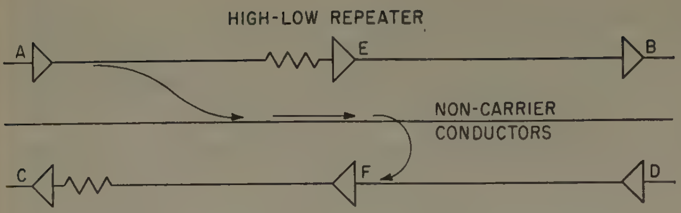

Figure 5. Interaction crosstalk high-low repeater

In some cases noise has been experienced on systems operating on cables without open-wire taps or drop loops. Here the longitudinal noise currents present on the sheath encountered a high impedance due to the presence of an insulating joint in the sheath and the noise was transferred thereby to the longitudinal circuits of the pairs. Certain capacitors used to by-pass insulating joints in the sheaths of voice-frequency cables do not effectively by-pass carrier-frequency currents due to inductance in the leads. Where the need for the insulating joint no longer exists, it has been permanently removed. In other cases the joint also has been bridged by a 4-microfarad capacitor having short straight leads.

Some use has been made of slot rejection filters as a stop-gap measure until the installation of suppression which does not impair the *N1* message circuit. In order to minimize the impairment to speech transmission, only narrow-band slot filters are employed and this means, of course, that the method is satisfactory only when the interference is a single-frequency tone. It is admittedly not a desirable measure since the effectiveness of the suppression is reduced by variations in the interfering frequency. It obviously is undesirable to use slot rejection filters on circuits which may be operated in tandem with other circuits which also may contain filters tuned to a different frequency.

4. *Nonsoldered Cable Pair Joints.* Occasionally *N1* systems are operated in part or entirely over cable pairs with nonsoldered joints. This usually occurs only in the case of older exchange cables since it is now common practice to solder new cables which are candidates for *N1* operation. The defect in nonsoldered joints is due primarily to a barrier of oxides and possibly sulfides. The joint resistance may be variable due to temperature changes or vibration, and may produce a noise sounding like thermal noise with superimposed irregular clicks and pops. Where a cable on which *N1* carrier is to be installed is known to have a bad history from the standpoint of variable resistance, it is possible to make a series of tests over a period of time to determine which pairs are suitable for carrier use.

The presence of d-c supplying repeaters with power is thought to help minimize noise production in the nonsoldered joints. Where such power is not supplied over the cable pairs, it is possible to supply up to 20 milliamperes of bleeder current to aid in stabilizing the joint resistance.

CONTROL OF CROSSTALK

THE SOLUTION to a number of crosstalk problems present in other open-wire and cable-carrier systems has been facilitated by the design of the *N1* system. For example, frequency frogging has solved the run-around crosstalk problem at repeaters without requiring the introduction of loss in the longitudinal path as in open-wire systems, or the use of separate cables which permit pair frogging as in the case of Type *K* cable carrier. Also, the compandor per channel helps to control far-end and other types of crosstalk without the use of frequency staggering as in 3- and 12-channel open-wire systems or the provision of the intersystem crosstalk balancing associated with Type *K* carrier.

It is possible to operate a large number of *N1* carrier systems in most of the cables now in the telephone plant. In quadded cables it is expected that carrier may be operated on substantially every quad. In nonquadded cables, where the coupling losses are somewhat lower, crosstalk poses more of a problem. Anticipating this the thermal noise generator was provided in each transmitting group unit. However, as previously noted, it has not been necessary yet to introduce this crosstalk masking noise.

Crosstalk Design Objective. The Bell System has developed a system for rating performance as controlled by crosstalk which takes into account the distribution of talker volumes at the originating toll switchboard, the number of disturbing circuits, the rms value of the current ratios in each group of similar crosstalk couplings, and the masking effect of various types of noise, including babble or the crosstalk from multiple disturbers. The crosstalk couplings between the combinations of quads or pairs in a cable vary over a considerable range. It is evident, therefore, that, if a limited number of the conductors in a cable are employed for carrier operation, the probability of hearing crosstalk from other systems is reduced. Without elaborating further on the fine points of crosstalk index, as this criterion of performance is known, it may be noted that good performance will be achieved if the coupling loss between the toll switchboard at the transmitting end of a *disturbing* circuit and the toll switchboard at the receiving end of the *disturbed* circuit is about 38 decibels. This assumes that no noise is present on the disturbed circuit. With the masking noise, comparable performance will be realized with a coupling loss of about 33 decibels.

Crosstalk Advantage of the Compandor. The expandor at the receiving terminal of the *N1* channel introduces a loss of 28 decibels as long as the total side-band power at its input is below the level at which the expandor begins to "open up." This is always true in the case of the crosstalk encountered in commercial practice. The 28-decibel loss effectively attenuates the crosstalk during the silent interval when it is most objectionable. If the disturbing circuit is not compandored, full credit can be taken for this attenuation but if it is equipped with a compandor the effect of its compressor on raising the average talker volume at the transmitting terminal must be recognized. Under present-day conditions, the *N1* compressor increases the crosstalk potentialities by about 7 decibels and hence the net compandor advantage for crosstalk between *N1* systems is 28 − 7 or 21 decibels.

Transverse Far-End Crosstalk. Figure 3 shows the path of transverse crosstalk in which *AB* is the disturbing circuit and *CD* is the disturbed circuit. Since the crosstalk loss per unit length varies inversely with frequency, it is evident that the coupling loss between *AB* and *CD* will be less in the first repeater section than in the second. It also may be noted that in the first section, the crosstalk loss for channel *12* using a 256-kc carrier will be less than for channel *1* which uses a 168-kc carrier. However, in the second repeater section channel *12* operates on a 48-kc carrier at which frequency the coupling loss is greater than for channel *1* with its carrier at 136 kc. It has been found that with an even number of repeater sections the amount of far-end crosstalk is substantially the same on all channels and that the coupling loss is about the same as would apply between channels using a carrier frequency of 165 kc in every repeater section. Since the far-end coupling loss versus frequency characteristic for cable pairs is usually free of peaks and valleys, it is possible to estimate crosstalk for all channels on the basis of 165-kc couplings.

The coupling losses between pairs in the same quad are relatively low unless intraquad balancing is employed. However, by utilizing the two pairs of a quad for the same *N1* system, the effect of this low coupling loss is not significant since different bands of frequencies are transmitted over the two pairs. The coupling loss between equal level points on the pairs in different quads is considerably higher, the rms loss being in the order of 75 decibels per mile at 165 kc and the 1 per cent minimum roughly 10 decibels less. These losses may vary ±5 decibels depending upon the size of cable and type of construction (that is, long pair twist or short pair twist) but are typical of present-day cables in the 30-quad size. With couplings such as this the transverse crosstalk in quadded cables is not serious even on systems up to 200 miles or more in length, and no cable balancing is required. When placing new quadded cables primarily for *N1* carrier use certain splicing precautions may pay dividends in lower crosstalk, particularly when the cable is of small size. This effect of splicing will be discussed a little later.

The situation with nonquadded cables is different, particularly in the case of older types in which the same length of pair twist was used for all pairs in the cable. For example, the rms coupling losses in nonstaggered twist cables run about 55 decibels per mile at 165 kc. With improved manufacturing methods and more rates of twist, it has been possible to raise the rms coupling loss in a present-day 25- or 26-pair unit of pulp-insulated 19-gauge cable to about 68 decibels per mile at 165 kc with the rms coupling loss between units about 9 decibels higher. Even better performance resulted in some experimental cables utilizing polyethylene insulation and 10 different rates of pair twist.

Control of Transverse Crosstalk. When *N1* systems are placed in existing quadded cables little is done other than to remove any loading that is present on the carrier pairs and whatever voice-frequency crosstalk balancing capacitors have been installed in the loading splices. The crosstalk balancing units in other splices are removed only if the cable is opened for some other reason. Building-out stubs which were placed to provide uniform loading section length are removed since these no longer serve a useful purpose and may introduce considerable crosstalk.

When new quadded cables are placed for *N1* use, they are frequently of small size since even a 27-quad cable is capable of providing 300 message channels if fully developed for carrier use. As the size of a cable is reduced, it is obvious that the chance for any two quads to occupy adjacent positions is increased. The coupling between adjacent quads is much greater than between alternate or more widely separated quads so the rms coupling loss decreases with size. In order to achieve the least crosstalk, therefore, it is desirable to splice the cable so as to equalize as nearly as possible the number of adjacencies between all *N1* carrier quads. Rather than leave the splicing plan entirely in the hands of chance, splices in small cables are sometimes planned using the so-called "number splicing" technique. This procedure insures as thorough mixing of the quads at each splice as is theoretically possible. With larger cables simplified random splicing techniques are generally adequate.

More care is desirable when engineering carrier on nonquadded cables, since the over-all coupling losses are somewhat lower than in quadded cables and the couplings vary over a wider range. If the cables are in place, the amount of crosstalk is estimated, taking into account the length and coupling loss in each cable section and the number of possible disturbing channels. Should the expected performance fail to meet the desired objective, the use of cables with higher coupling losses is the first consideration. If this is not feasible it is possible to select pairs in each repeater section so as to minimize the effects of bad coupling. This is accomplished by assigning to the same frequency group only those pairs between which the coupling losses are relatively high. In some cables there may be a few bad actors which do not lend themselves even to this treatment and therefore they must be discarded from carrier use. The possibilities for improving performance by pair selection are great but so are the costs of the coupling measurements. Practical application of the technique, therefore, is expected to be rather limited.

When placing new nonquadded cables, the approach is similar to that for existing cables except for the opportunity to increase the coupling loss by controlling the splicing.

Crosstalk in Lateral Cables. A situation where it has been desirable to locate a high-low repeater at the end of a lateral cable is shown in Figure 4. The repeater section to the west has been assumed to require the use of a pad at the input to the repeater at *E*. The repeater section to the east requires no such pad and there is, therefore, in the lateral cable a level difference between pairs in the same frequency group. If the level difference at 256 kc is greater than about 27 decibels with a lateral cable length of about 200 feet, the resulting near-end crosstalk from *A* to *B* may

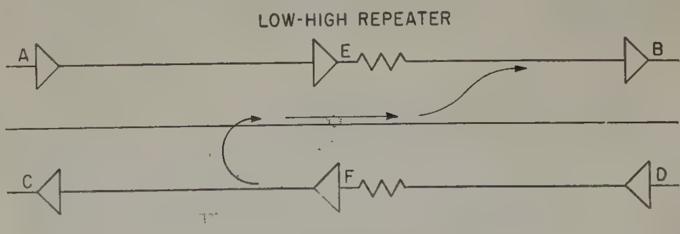

Figure 6. Interaction crosstalk at low-high repeater

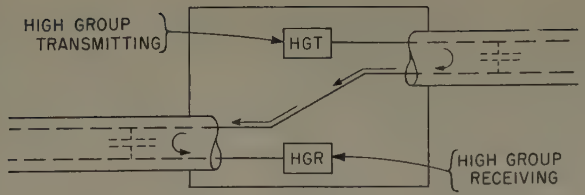

Figure 7. **Interaction crosstalk at terminal**

add significantly to the crosstalk already present at terminal *B*. The remedy is to reduce the level difference in the lateral cable either by equalizing the length of the repeater sections or by moving part or all of the span pad from the input of the repeater at *E* to the output of the repeater at *A*.

As the length of the branch cable is increased the coupling loss is decreased and the corresponding level difference at 256 kc must be reduced. When more than one lateral cable is used on the same system, the effects of all such cables in contributing to the near-end crosstalk must be evaluated.

Consideration of lateral cable crosstalk between low-frequency groups is not generally required since the coupling losses in the cable are higher. At low-high repeaters, however, differences in high-frequency levels due to the use of pads at the repeater outputs are subject to the same restrictions as just outlined.

Interaction Crosstalk at a Repeater. The interaction crosstalk path at a repeater by way of paralleling noncarrier conductors is shown in Figure 5. If the length of the repeater section from *A* to *E* is shorter than from *D* to *F*, requiring the use of span pads as shown, there will be a level difference between channels operating at the same carrier frequency. When the 256-kc level difference at a single repeater exceeds about 27 decibels, the amount of crosstalk through the interaction path represented by the arrows may contribute significantly to the crosstalk at *C*. Again since the loss in this coupling path is higher at the low frequencies the interaction crosstalk is not generally a problem at low-high repeaters.

This type of interaction crosstalk may occur wherever successive repeater sections differ in length. It is necessary, therefore, to be sure that the combined crosstalk from all high-low repeaters does not become excessive. In general this will be the case if the 256-kc level difference between the inputs from east and west at each high-low repeater is limited to 16 decibels or less.

Occasionally it is desired to place a span pad or artificial line at the output of a low-high repeater as shown at *E* in Figure 6. Since the levels at the repeater outputs are the same, the level on the cable pair at the output of the repeater at *F* will be higher than on the pair at the output of the pad at *E*. Again there is an interaction path through the noncarrier pairs, and the same 27-decibel level difference objective applies.

Interaction Crosstalk at Terminals. At the beginning of the discussion of crosstalk, reference was made to the frequency frogging at each repeater which facilitates the control of crosstalk between high- and low-level pairs in the same cable. In most cases this frequency segregation of high- and low-level signals also is maintained at the carrier system terminals by specifying either "high group transmitting–low group receiving" terminals or "low group transmitting–high group receiving" terminals in a given office.

There are instances, however, in which the operation of high group transmitting and high group receiving terminals in the same office is desired. Figure 7 illustrates how crosstalk from the high group transmitting terminal can appear as near-end crosstalk on noncarrier pairs in the same cable, then travel longitudinally through the office to noncarrier pairs in another cable containing *N1* systems using high group receiving terminals. When there is no equipment on the noncarrier pairs the longitudinal loss of the office wiring may be substantially 0 decibels. In quadded cables the total coupling loss may be as low as 100 decibels at 256 kc at which frequency the level difference between the two carrier terminals may be over 60 decibels.

The longitudinal loss through the office is increased by the presence of repeating coils and voice-frequency repeaters on the noncarrier pairs and also varies with the degree of interconnection between the noncarrier facilities in the two cables. While the metallic circuit and phantom circuit losses may be in the order of 50 to 100 decibels, the ground return loss generally will be in the order of 10 to 20 decibels. If the total loss in the interaction path is inadequate it may be increased by inserting longitudinal suppression coils in the noncarrier pairs. Care also must be taken to insure adequate physical separation of the carrier terminals and the associated wiring. At present it is believed that this will be achieved by using separate, even though adjacent, bays for the two groups of terminals and by separating the wiring by the width of at least one bay.

CONCLUSION

MOST OF THE *N1* carrier noise problems were anticipated in connection with the original development and the engineering of the specific projects. However, in some instances the solutions have been learned from experience, the best teacher of all. *N1* circuits now are operating under conditions considerably more severe than originally expected and the trend doubtless will continue. As for the effectiveness of the control measures, it may be noted that in a recent survey embracing over 4,000 channels, only 8 per cent of the channels exceeded the noise objective and on half the circuits the noise conditions were at least 8 decibels better than the objective. In a number of cases, certain channels are being kept out of service until one or another of the measures outlined can be applied. As further noise suppression is installed, many of the working channels also will be benefited. The noise survey includes the effect of dial office noise but probably does not reflect fully atmospheric static noise since the measurements were made at random times throughout the year.

No comparable crosstalk surveys are available, but discussion with operating companies, and measurements on some long systems operating in nonquadded cables indicate that adequate control of crosstalk also has been achieved.

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1. A New Telephone Carrier System for Medium-Haul Circuits, **R. S. Caruthers, H. R. Huntley, W. E. Kahl, Ludwig Pedersen.** *Electrical Engineering,* volume 70, August 1951, pages 692–7.

A Low-Height 15-Ton Mine Locomotive

J. W. BRAUNS

WITH THE ADVENT of mechanical mining it has become possible to mine coal from seams formerly considered too narrow for practical working. As a result, locomotive designers had to produce a haulage locomotive, big enough to handle the production of coal in seams 30 to 42 inches high. Moreover, the locomotive must conform to the requirements for standard haulage-type locomotives as regards high continuous tractive effort, latest traction motor design, sturdy construction, accessibility of equipment, and capability to accelerate a train.

A 15-ton low-height trolley locomotive has been developed to meet these requirements. It has a minimum height of 26 inches, which is increased to slightly over 27 inches if larger wheels are used to obtain higher speed. It is 248 inches long and 78 inches wide over journal boxes.

Each of the two axles is powered with a frame-mounted d-c series-wound commutating-pole self-ventilated traction motor having a 1-hour rating of 95 horsepower at 250 volts. Class *B* insulation is used throughout. The motor is connected to a double reduction gear box mounted on the axle through a drive shaft with a double universal joint and a slip joint. All motor and drive bearings are of the antifriction type except the suspension bearings on the axle.

With 23-inch wheels the rated drawbar pull is 7,500 pounds at 7 miles per hour, with 250 volts on the trolley. The use of 25-inch wheels and high-speed gearing gives the same rated drawbar pull at 10.5 miles per hour. The maximum starting drawbar pull is 9,000 pounds.

Both motors are permanently connected in parallel for operation from a 250-volt trolley. The control provides 10 steps in motoring and 7 steps in dynamic braking. This permits rapid acceleration and smooth handling of trains. The master controller, of the cam-operated type, actuates electropneumatic contactors and an electropneumatic reverser. A motor-driven compressor supplies air for locomotive brakes, control, and sanders. A motorman's valve controls the application of air to two equalized brake cylinders which operate the locomotive brakes. The various controls are all conveniently located and compactly arranged to allow for easy, safe operation.

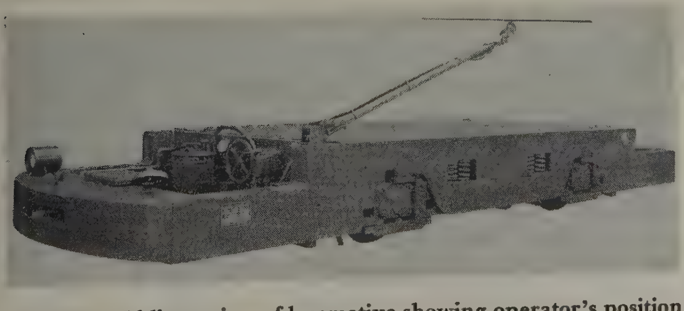
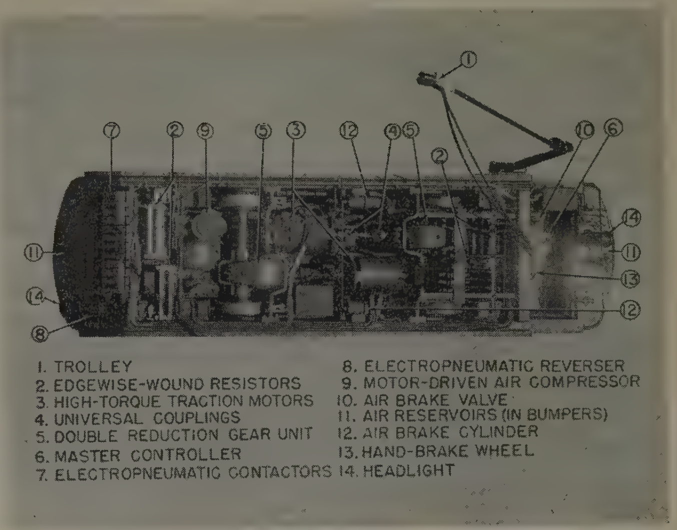


Figure 1. Oblique view of locomotive showing operator's position and controls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1. TROLLEY
2. EDGEWISE-WOUND RESISTORS
3. HIGH-TORQUE TRACTION MOTORS
4. UNIVERSAL COUPLINGS
5. DOUBLE REDUCTION GEAR UNIT
6. MASTER CONTROLLER
7. ELECTROPNEUMATIC CONTACTORS
8. ELECTROPNEUMATIC REVERSER
9. MOTOR-DRIVEN AIR COMPRESSOR
10. AIR BRAKE VALVE
11. AIR RESERVOIRS (IN BUMPERS)
12. AIR BRAKE CYLINDER
13. HAND-BRAKE WHEEL
14. HEADLIGHT
Figure 2. View of locomotive from above showing location of principal pieces of equipment

Trolley poles may be mounted on either or both sides of the locomotive. A special type of trolley-pole socket with an air-actuated lifter is available which raises the trolley base enough to permit the pole, when in the down position, to be swung across the top of the locomotive. A trolley retriever, used to prevent damage in case of dewirement, functions on no voltage and lowers the pole if it leaves the wire. Operation can be made either automatic or manual, thus permitting the locomotive to pass insulated joints in the trolley wire without the pole being retracted.

Overload protection is furnished to the equipment by means of relays suitably connected in the circuits.

The locomotive can be arranged for operation with two units connected together under the control of one motorman. In this case provision is made for emergency brake application if, for any reason, the units should separate. A safety drawbar, in addition to the regular drawbar, is provided between units.

In spite of its strictly limited dimensions, this low-height locomotive has the same advanced design features and sturdy construction that have proved eminently successful in the standard line of haulage locomotive. Adequate space is provided for both the motorman and trip rider. Particular attention has been paid to details that promote safety and reduce the fatigue resulting from working in close confines.

Digest of paper 53-365, "A Low-Height 15-Ton Mine Locomotive for Low-Vein Haulage," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Middle Eastern District Meeting, Charleston, W. Va., September 29–October 1, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Generator Relaying for Single-Axis Short Circuits

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FOR FEAR that overcurrent relays might trip off the unit on overload when it is needed most, generators are usually not provided with relays to respond to balanced external faults. This is satisfactory practice because balanced faults on the system can be tolerated by the generator for an appreciable time. However, experience now indicates that the more closely designed modern generators should be provided with relays to detect the presence of unbalanced external faults that are not cleared in a proper time, since these may result in damage to the generator.

Single-axis short circuits, such as phase-to-phase faults at the generator voltage or phase-to-ground faults on the high-voltage system, even though the fault currents would be smaller in magnitude, may produce severe heating of the rotor of the generator if they are permitted to persist for a longer time than the usual time delay associated with backup protection.

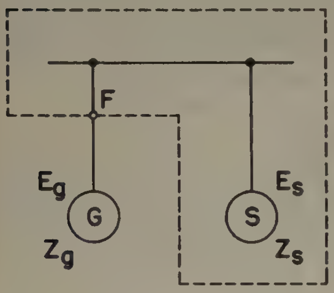

Figure 1. Schematic diagram of system problem reduced to a 2-machine problem

It is assumed here that a Y-delta transformer is used as a step-up transformer, with its high-voltage neutral solidly grounded and the delta winding connected to the generator. A single line-to-neutral fault on the high-voltage side then is essentially equivalent to a line-to-line short circuit with fault impedance at generator terminals.

The rotor winding and damper circuits of a synchronous machine compare essentially with the squirrel-cage windings of an induction machine. Balanced 3-phase faults involve only positive sequence currents producing magnetomotive forces which are in synchronism and do not induce alternating voltages in the rotor circuits. Unbalanced faults result, however, in positive- and negative-sequence short-circuit currents in the armature and the negative-sequence currents will induce double-frequency (120 cycles) currents in the rotor damper circuits, including the field winding. These rotor currents will be proportional to the negative-sequence currents in the armature. Because of the small depth of penetration of 120-cycle currents, about 90 per cent of this current will find paths near the rotor surface, including the slot wedges. The damage results from the heating of the rotor and the weakening of mechanical strength, and eventual failure of the slot wedges.

For the computation of the negative-sequence current in the generator, the general problem of a generator *G* on a large system may be simplified to a 2-machine problem. Figure 1 shows the generator under investigation, *G*, and the system which is reduced to an equivalent generator *S*; the fault is at *F*.

The initial value I_2'' of the negative sequence current in the generator stator winding depends essentially only upon the generator *G* and its subtransient reactance X_d'' and is not affected by the system to which the generator is connected:

$$I_2''=\frac{E_g}{2X_d''}$$

This negative-sequence current has relatively very little decrement and in a matter of seconds the magnitude will depend primarily on the large system *S* to which the generator is connected, approximating

$$I_2=\frac{E_s}{2Z_2}$$

This later value, I_2, will not be much smaller than the initial value, I_2'', while the positive sequence component of the current in the generator decreases during the same time to a relatively small value.

The rotor heating is a function of time. The new American Standards Association Standard *C-50* for generators would indicate a time limit of less than 2 seconds for a phase-to-phase fault at generator voltage while a fault on the high-voltage side of a generator transformer may be permitted for nearly 5 seconds without resulting in damage to the generator.

For this backup protection of the generator, overcurrent relays are not satisfactory and even with voltage restraint they do not respond to a function comparable to the rotor heating.

A phase-balance relay is satisfactory only for a short time since the stator current of initial value $I''=\sqrt{3}\,I_2''$ soon becomes primarily negative sequence (I_2, as given), which is also balanced. More desirable arrangements are relays that respond either to negative-sequence stator current or to 120-cycle currents in the rotor field winding. For such a relay, an inverse time characteristic which approximates rotor heating may be a preferable solution.

Digest of paper 53-188, "Backup Protection for Generators," recommended by the AIEE Committee on Relays and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Southern District Meeting, Louisville, Ky., April 22–24, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Economic Factors of Small-Capacity Hydroelectric Stations

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The use of induction generators in semioutdoor plants, simple relay and water-wheel controls, and fully automatic features has reduced materially the plant investment, operating, and maintenance costs, thus making the use of small hydroelectric sites more desirable. The economic aspects of two actual induction generator plants are described.

THE ATTRIBUTES of an induction generator will make attractive small hydroelectric sites with heads of 20 feet or more which otherwise would be impracticable.[1] Induction machines are feasible as adjuncts to large synchronous stations. The inherent merits of the induction generator will provide a low cost source of kilowatt-hours.[2,3] The merits of such a simplified generator undoubtedly will change the idea of it being a scientific curiosity and in the future will appeal to the central station engineer as a desirable addition to his equipment.

ENGINEERING ECONOMY

THE DESIGN SHOULD embody simple instead of complicated forms. Good design is complete with no guesses for the contractor or construction superintendent and hence leaving no claims for extras because of subsequent revisions and changes.[4,5] Every time an uncertainty is removed, the price is lowered. Each contract should be prepared with the idea that it may go to court. Preferred methods instead of a multiplicity of design elements can save an amazing amount of busy design engineers' time and reduce the construction costs.

Increases in cost of coal, oil, and gas fuels will continue to make hydroelectric plants more inviting. Additional ponds and storage reservoirs on the same stream above existing hydroelectric plants will increase the hydroelectric plants' values.

ECONOMIC TRENDS IN DESIGN AND ARRANGEMENT

A NUMBER OF semioutdoor type of generating stations have been built in which all or a part of the conventional powerhouse superstructure was omitted.[6] In some instances the generator room floor became the station roof, the generator being protected by a concrete or metal housing. An outdoor gantry crane usually was provided for removing the water-wheel and generator parts to one end of the station, where it could be lowered through a hatch to the inside repair bay below. On systems where truck-mounted mobile cranes are readily available and accessible for small plants, the power plant crane could be omitted.

Closed ventilation systems normally are not recommended in generators below 3,000 kva unless the cooling air is too warm and is contaminated. In cold climates the cooling air can be used to heat the powerhouse enclosure.

The new large 3-conductor flexible-armored-sheath high-voltage generator cables can save conduit and labor, and result in a neat, dependable, and safe arrangement. Station power can be obtained from the hydroelectric plant switchgear bus if generator circuit breakers are provided. Such power should be 3-phase 4-wire 120/208 Y volts for power and lighting requirements. If a unit system is employed, a 3-phase station power transformer can be provided in the substation.

All hydroelectric plants should be equipped with relays for full automatic operation. Labor rates and rules have necessitated these economy measures for new plants. Where the headwater is maintained at a definite level, water-level float control may be combined with the other automatic features.

GREATER ECONOMY FOR LOW-HEAD HYDROELECTRIC PLANTS

DEPENDING UPON the variations in head and flow conditions, various alternatives may be used to reduce the initial cost and operating expense of the hydraulic turbine equipment.

In general, it is desirable to utilize higher speeds because of reduced generator costs, but in many cases the higher specific speed of the turbine requires a lower setting and introduces additional costs which may offset the saving in the generator and turbine.

Since most of the smaller capacity hydroelectric plants operated by utilities today are connected to large systems and are not required to regulate, the use of an induction generator permits certain economies in the prime-mover equipment. With voltage and frequency controlled by the power system, the turbine governor may be omitted and a simple motor-operated device substituted to open and close the turbine gates, or to position them for part gate operation. For physically large turbines, solenoid- or motor-operated oil valves may be used in connection with servomotors and a simple oil-pressure system. Thus,

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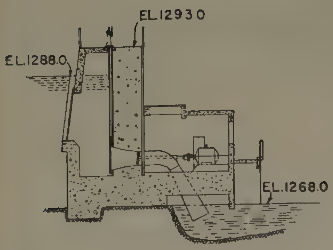

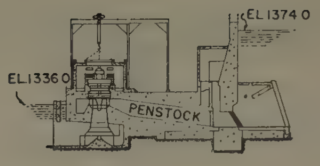

Figure 1 (left). Section through Lower Paint plant. **Figure 3 (right).** Similar view of Way Dam plant section

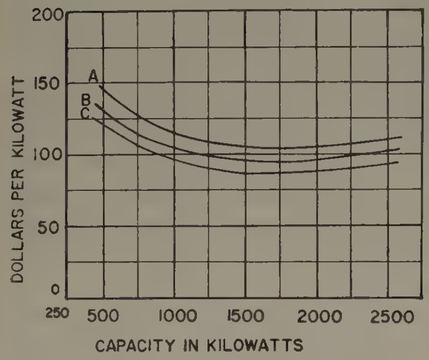

Figure 2. Cost comparison of fixed-blade turbine, generator and simple switchgear: A—Synchronous with gates and governor; B—Induction with motor or oil-operated gates, but no governor; C—induction with no gates or governor

by means of time switches or a float-level device to dictate the operation of the gate mechanism, the unit may be arranged to operate during selected periods such as peak loads or for continuous operation at part gates consistent with river flow or ponding conditions. This method of control is equally adaptable to the Francis fixed-blade propeller, and manually adjustable-blade propeller types of runners.

In some instances, it is also practical to omit the turbine wicket gates and gate mechanism and further reduce the turbine cost and maintenance expense. To do so, however, the turbine output would be constant at any head and its discharge could not be controlled intermediately. This type of equipment could be used only at such sites as require continuous discharge for minimum stream flow, for regulation of flow through other plants along the same stream, or where there is sufficient storage to accumulate enough water to operate the turbine at full discharge during peak loads or longer periods. Obviously, some means must be provided for admitting or withholding water from this turbine. In most cases, this could be done by the head gates at the intake of open flume or concrete spiral types, or by means of a shutoff valve in the penstock if a penstock is warranted by the operating head and plant design.

A further simplification in the smaller sizes of hydraulic turbine equipment can be effected by eliminating the head cover and its support, and substituting a curb ring with radial arms to support the guide bearing. The turbine then would be embedded in the floor or wall of the flume and the shaft extended to the generator. Such a turbine of about 100-kw capacity is presently in operation, as shown schematically in Figure 1. A unit of this type may result in slightly lower operating efficiency, possibly several percentage points, but may prove economical if efficiency is not of primary importance.

Since motor operation of the turbine gates or the head gates is relatively slow, sudden loss of electric load on the generator would cause quick acceleration of the unit's speed, and both generator and turbine rotating parts must be designed to withstand full runaway speed for relatively long periods. This, however, does not impose any special problem since all hydroelectric units usually are designed for such conditions anyway.

Unfortunately, the Kaplan or governor-adjusted blade propeller turbine does not at the moment readily lend itself to much simplification in design for further cost reduction.

Figure 2 shows the relative costs per kilowatt of hydroelectric equipment from 500 to 2,500 kw capacity. They are applicable to a site at which a normal net head of 20 feet is available. Unit speeds, although not shown, are based on a specific speed of about 150 for vertical shaft fixed-blade propeller-type turbines. For capacities up to 1,500 kw the turbines are of the open flume type, while in the larger sizes, turbines of the concrete, semispiral casing type are used. Generators are of the standard open type, with exciters included for the synchronous machines. Also included is a standard control cubicle, except that automatic synchronizing equipment has been added for the synchronous generators.

Hydroelectric stations with generation and switchgear equipment previously described not only reduce the initial cost of original plant and its fixed charges, but more importantly reduce by a considerable degree the labor charges for maintenance and operation. Thus where in many cases marginal operation only can be expected from a conventional type of plant, the simplified arrangement would enable the station to be operated at a profit. This is especially true of small-capacity plants where an operator normally has little work to do but must be kept on the job a substantial part of the time, while at a plant with minimum equipment he might be required to attend it only a few hours a week or at even less frequent intervals.

ECONOMICS OF INDUCTION GENERATOR

TABLE I SHOWS a comparison in performance between 2,500-kw synchronous generator and a 2,500-kw induction generator. It is interesting to observe how well the induction-generator efficiency compares with that of the synchronous generator. The former is 97.0 per cent, and the latter 96.9 per cent.

The Way Dam quotation for an identical generator indicates that the induction machine costs 91 per cent of an identically rated synchronous machine with exciter. The latest cost comparison of induction generators, if designed as such, indicates a slight increase in cost of such a machine over an equivalent synchronous machine. However, there are additional items of savings that enter into the total plant installation. The advantages of the induction generator are summarized as follows:

1. Occasional plant inspection and ease of control.
2. Electric connections extremely easy.
3. No exciter, brushes, or slip rings.

4. No use of power to drive exciter.
5. No costly governor mechanism.
6. No voltage regulator.
7. Reliability (rugged rotor design).
8. Electric overloading difficult.
9. Minimum short-circuit current.
10. Favorable first cost.
11. Simple relay protective equipment.
12. Ideal for high-speed prime movers (absence of salient pole pieces).
13. Freedom from harmonics and good damper action.

On the other hand, the inconveniences of the induction generator are as follows:

1. Necessity of supplying magnetizing current from the connected system.
2. Inability to operate alone on the system without being equipped with capacitors.
3. Reduction in power factor at light loads.
4. Uncontrollability of bus voltage.

In most cases, regulation of the voltage is not necessary especially if the hydroelectric plant is connected to an extensive system. The larger hydroelectric and steam plant generators in other plants provide the regulation and the necessary kilovars.

The maintenance of induction power plants is very low and the output can contribute to help supply power in the adjoining distribution areas, thereby minimizing transmission losses. Such a plant should connect itself automatically or start generating whenever electric power is re-established to the plant. These facilities must be provided with a minimum of capital and yet be electrically and mechanically simple and dependable. Some such hydroelectric plants can be remotely controlled from a nearby attended plant. In others, the plant can operate automatically according to the water level in the pond. A float can provide the initiating start and stop control.[7]

Speed regulation on the turbine driving an induction generator is not necessary since it is the speed of the system which governs the revolutions per minute. It is sufficient in the larger units to have a speed limiter which shuts down the water wheel in the event of disconnection of the generator from its electric system.

WAY DAM GENERATOR PLANT

An 1,800-kw induction-generator hydroelectric power plant was placed in service on December 4, 1949, by the Wisconsin Michigan Power Company. The plant was built in conjunction with the existing Way Dam which was completed early in 1941 to form the Michigamme Reservoir on the Michigamme River in Michigan's Upper Peninsula. A careful economic analysis indicated the practicability of the installation of a small hydroelectric plant at this dam site. It impounds a reservoir covering 7,000 acres at a maximum head of 38 feet.

The reservoir normally is filled to capacity about the middle of May. It then remains at full capacity for about 2 months until drawdown is started during the dry summer months. During this period the reservoir may be drawn down from 5 to 15 feet until the beginning of fall rains, at which time the reservoir is again refilled as much as possible in preparation for the coming winter storage requirements. Drawdown is usually complete between the first of March and the first of April.

Table I. Comparative Study—Two Designs[9]

A 2,500-Kw Synchronous Generator and a 2,500-Kw Induction Generator Both Supplying the Same Power-Factor Load. Exciter Power Requirements Not Included With Synchronous Generator

Item	Synchronous Generator	Induction Generator
Core loss	30 kw	30 kw
Primary I^2R loss	9.5	10.5
Secondary I^2R loss	6.5	2.8
Windage	35.0	35.0
Total loss, excluding bearings	81.0 kw	78.3 kw
Efficiency, excluding bearings	96.9 per cent	97.0 per cent
Per-cent slip at rated load	0.0 per cent	0.11 per cent

The plant superstructure is of a semioutdoor design as shown in Figure 3. It is constructed of reinforced concrete and structural glass block and is of sufficient area and height to house comfortably only the generator and its associated control apparatus. Ceiling height is 12 feet, which does not permit the installation of an indoor crane for servicing. This function is accomplished by means of an outdoor traveling hoist which is able to transfer material and apparatus into and out of the plant through a circular hatch-covered opening 13 feet in diameter located above the generator. This hatchway is large enough to accommodate the largest piece of equipment which might need to be passed through it.

The generator is driven by a vertical fixed-propeller turbine rated at 2,400 horsepower and 225 rpm at 35 feet of net effective head. Actual gross operating head varies from a maximum of 38 feet to a minimum of zero.

Cooling air for the generator is drawn through ducts under the building floor into the generator pit and then passes up through the rotor and stator before being discharged through louvers in the upper part of the building wall.

The vertical shaft induction generator* installed in the plant is rated at 4,160 volts and 1,800 kw at 80-per-cent power factor.

The rotor resistance is less than for an identical induction motor, so as to improve the efficiency. The rotor is of the simple squirrel-cage design. The generator has no exciter, governor, field rheostat, voltage regulator, synchroscope, d-c ammeter, d-c voltmeter, or d-c bus.

A d-c motor operates the gate control on the water wheel. This motor with its associated mechanical load-regulating device provides a simple method for controlling the gate opening and thus the output of the machine. By means of a time clock and mechanically operated limit switches on the gate control mechanism, the output of the generator can be set at any predetermined point. A 48-volt battery is used to operate the motor.

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* *Way Dam Induction Generator:* 1,800 kw, Allis-Chalmers Manufacturing Company, 4,160 volts, 312 amperes, 3 phases, 60 cycles, 230 rpm. Continuous 100-per-cent load stator at 60 degrees centigrade. Normal ohms 7.7, magnetizing reactance per unit 2.56, subtransient reactance per unit 0.22, stator resistance at terminals at 25 degrees centigrade is 0.181 ohm, full load slip 1.42 per cent. *The Water Wheel:* rated 2,500 brake horsepower, made by Allis-Chalmers Manufacturing Company, 35-foot head, 225 rpm, serial number *1224*, vertical fixed-propeller turbine.

The single-line diagram for this plant is shown in Figure 4. All protective and other relaying devices are indicated with the exception of the turbine bearing temperature relays and the bearing cooling water supply protective equipment.

A small distribution transformer within the cubicle on the line side of the 5-kv air circuit breaker provides local single-phase power and relay potential. Surge protection is provided on the incoming 69-kv transmission line at the substation and also on the generator leads in the cubicle. Within the plant is one duplex switchboard cubicle and one 5-kv switchgear cubicle.

WAY DAM AUTOMATIC OPERATION

THE UNIT is placed in automatic operation by turning the control transfer switch to the automatic position. With the headgate open, all protective devices set, and the generator breaker open, the starting sequence is initiated by turning the master control switch to the start position. The turbine gates then will open automatically to the preset minimum load point. When the unit reaches synchronous speed the generator breaker is closed by the operation of a mechanical-electric speed switch and the generator then is connected to the energized bus.

The final gate position now is determined by a time switch which causes the gates to continue opening further to the load position determined by the adjustable limit switches on the gate control mechanism. The machine now will run continuously as a generator. The time switch will determine the generator output automatically by changing the gate position at predetermined times. The time clock with its associated apparatus permits greater output during peak load periods and less output during off-peak periods.

In an ordinary shutdown the gates are closed first and the breaker is not opened until the generator drops below synchronous speed. This type of shutdown occurs through the operation of the master control switch or through the closing of one or more of the protective relays as indicated on the diagram in Figure 4.

On an emergency shutdown the breaker is tripped immediately. Conditions causing emergency shutdown are serious enough to tolerate the overspeeds resulting until the gates are closed. Emergency shutdowns occur through the closing of one or more of the following protective relays:

1. Phase unbalance.
2. Overvoltage.
3. Generator differential.

These relays must be reset manually before the unit can be started again.

Upon the loss of bus voltage, an undervoltage relay opens the breaker immediately and the gates automatically begin to close. This would be a condition which would develop if the transmission line were in trouble. As soon as the bus voltage returns, all normal start operations begin automatically. The gates now open, bringing the machine to synchronous speed, the generator breaker closes and the gates continue opening to the preset load point.

An annunciator alarm is provided to call attention to the following abnormal conditions:

1. Hot bearing or loss of cooling waterflow (running).
2. A-c thermal overload or neutral current or generator overcurrent or reversed power flow.
3. Phase unbalance (avoid single-phase operation).
4. Overspeed.
5. Transformer overtemperature or low transformer oil level.
6. Differential relay operation.
7. A-c overvoltage or a-c undervoltage.
8. Loss of bearing cooling waterflow (starting).

WAY DAM MANUAL OPERATION

WITH THE transfer switch turned to the manual position, the master control switch is turned to the start position. The operator now may use the gate control switch to open the gates, bringing the generator up to synchronous speed as indicated by a tachometer. The generator circuit breaker then is closed manually and the operator next opens the gates farther until the generator is delivering the desired output, which is determined by the cubic feet of water available.

The annunciator and all of the protective devices are effective on manual operation. On loss of bus voltage, the unit will shut down but will not automatically start up again when voltage returns. The method of operation may be changed by an operator from manual to automatic or from automatic to manual at any time, whether the machine is running or not.

WAY DAM PLANT PERFORMANCE

THE PLANT PERFORMANCE has been very satisfactory. In 1950 it generated 9,563,000 kilowatt-hours; in 1951, 12,797,000 kilowatt-hours; in 1952, 9,276,000 kilowatt-hours. The average output for the 3 years was about 1,200 kw.

The generation output of this hydroelectric plant is directly dependent upon the available head. This happens to be a coincidence of several hydraulic factors. Figure 5 shows the relationship, as obtained from many operating points, between generating capacity in kilowatts and the gross head in feet. It may be seen that generation reaches zero at about 10 feet of head.

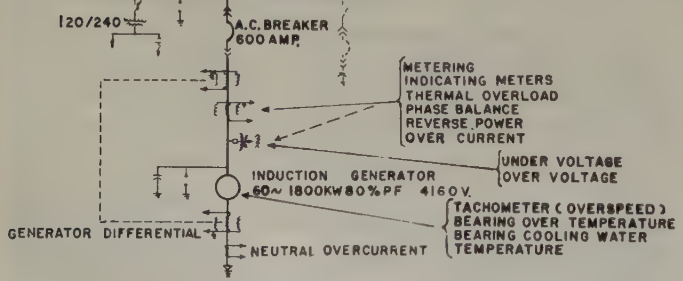

Figure 4. Single-line diagram of Way Dam plant

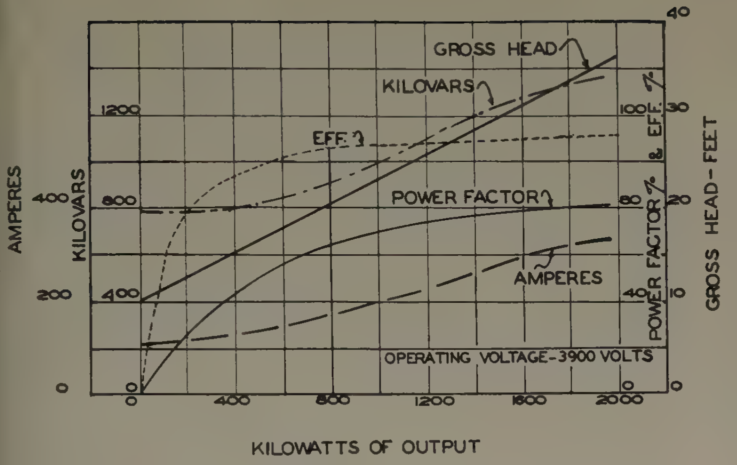

Figure 5 (left). Way generator operating characteristics.

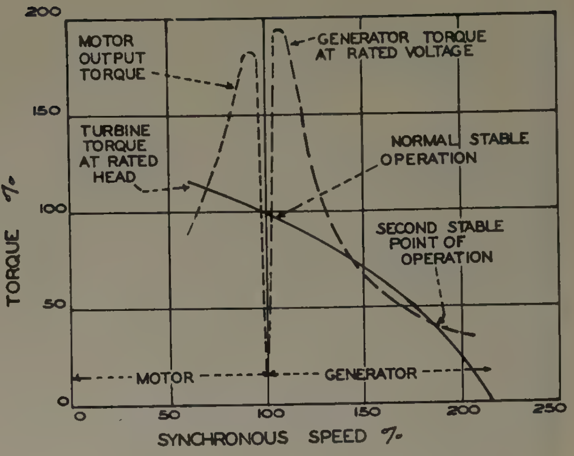

Figure 6 (right). Way generator torque characteristics

The curves reveal that the general operating characteristics of the induction generator, such as efficiency, power factor, overload, torque, and speed, are not greatly different from those of the induction motor. In an induction generator, the flow of power is from the rotor to the stator and in an induction motor the reverse is true.[8] See Table I for the comparison of the two types of machines. Figure 6 shows the torque curves of the generator and water wheel.

The operating and maintenance expenses for this plant have been unusually low. The simplicity of this induction generator has not required the usual expenses and attention that a synchronous hydroelectric plant requires. The operating and maintenance costs of this hydroelectric plant compare favorably with the most economical plants on the utility system.

The cost per kilowatt installed for this plant and substation exclusive of the dam (since this was for the reservoir project) was $197.70.

LOWER PAINT PLANT

Another small induction hydroelectric plant of the Wisconsin Michigan Power Company known as Lower Paint Dam Plant,† was first started on May 21, 1952, operating on a net head of 20 feet and developing 100 kw at 533 rpm. This plant was constructed at a new dam, where the water was diverted from the Paint River in Upper Michigan through a mile and a half long canal into the Michigamme River. At this plant extreme simplicity was foremost in the design. It was set inside the dam to obtain the maximum number of kilowatt-hours from the 85 cubic feet per second of water which is passed down the river 24 hours a day, 365 days a year, for maintenance of fish life and scenic beauties.

A hydraulic fixed-blade type of propeller rated at 155 horsepower, 514 rpm, was directly connected to a standard 3-phase 60-cycle 440-volt induction motor which operates as a 100-kw generator. The water wheel has no wicket gates, thereby holding the first cost to an absolute minimum. There is no governor on the turbine. The generator is somewhat like the Way Dam induction generator since it has a squirrel-cage rotor, no rheostats, no voltage regulator, no exciter, no batteries, and no overcurrent relays except those that are built in and are a standard part of a reduced-voltage starting cabinet. Figure 1 shows a sectional elevation of the plant. The wheel is shut down by a hand-operated vertical lift gate in the flume. If power fails on the circuit to this plant, the hydroelectric unit runs at run-away speed, namely, about 900 rpm. This speed, however, can do no harm to a simple propeller and a simple squirrel-cage rotor. When electric service is restored to the plant, the standard 150-horsepower starting cabinet throws half voltage instantly on the generator and the speed drops down from about 900 rpm to near synchronous speed. Then after several seconds delay, the starting compensator automatically throws full voltage on the generator and the speed is reduced slightly again and full generating output is produced. Figure 7 shows a 1-line diagram for this hydroelectric plant.

All the operations are fully automatic. An attendant visits this plant for a short time about once a week. Since the plant was placed in service it has generated about 70,000 kilowatt-hours per month. Its yearly output will be about 850,000 kilowatt-hours.

The cost per kilowatt of the wheel, generator, switchboard, and transformer for this plant and substation, exclu-

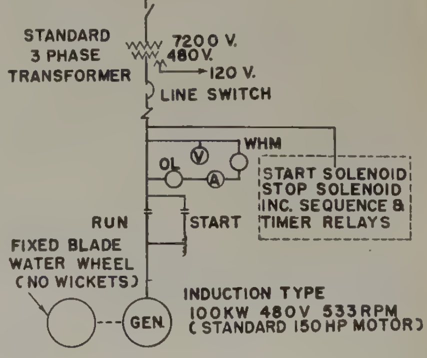

Figure 7. Single-line diagram of Lower Paint plant

sive of the dam (since this was for the diversion project), was about $247.00. The output from this plant is firm power.

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† *Lower Paint Induction Generator:* 100 kw, Allis-Chalmers Manufacturing Company, 480 volts, 145 amperes, 3 phases, 60 cycles, 533 rpm, continuous 100-per-cent load of 40 degrees centigrade, serial number *7-5128-19919-1-1*. *Water Wheel:* rated 155 brake horsepower, made by Allis-Chalmers Manufacturing Company, 20-foot head, 514 rpm, serial number *1267*, horizontal fixed-propeller turbine. Type *HARC-ARC-214 MS* Allis-Chalmers Manufacturing Company, 480-volt reduced-voltage squirrel-cage induction-motor control for use with above motor to be used as on induction generator.

CONCLUSIONS

ATTENTION OF recent years has been concerned with the development of large hydroelectric sites where minimum labor costs would result in the least cost per kilowatt-hour generated. Smaller attractive hydroelectric power sites have been overlooked. Simple automatic generating systems, such as the induction generator plants with full automatic equipment, should promote a revaluation of the development of sites below 50-foot heads and where outputs from 100 to 2,500 kw are available. The two plants just described illustrate approximately the maximum and minimum induction generator size which this article endeavors to cover.

Attention especially should be given to dam sites which control large reservoirs for hydroelectric generating sources. Any hydroelectric site with an adequate head where a dam must be maintained presents case studies worthy of economic development consideration. Also, throughout the country many abandoned hydroelectric plants and dam sites are known. Simplified plant design, which would provide a fully automatic unattended plant, offers new economic considerations for electrical utility companies. Furthermore, undeveloped sites are existing near adequate transmission lines that should be studied as possible low-cost sources of kilowatt-hours.

Experience has indicated conclusively that induction-generator hydroelectric plants are reliable and have many advantages. Such generators especially lend themselves to low-cost developments of automatic hydroelectric plants which easily can be applied to extensive utility networks. A utility system network generally has enough synchronous generators in service to permit many induction machines on its system, without impairing the maintenance of adequate machine excitation or system voltage regulation. Much of the economic analysis for hydroelectric plant development applies to synchronous generators also, should such units be preferred.

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Design of Transformers for Resistance Welding Machines

D. L. KNIGHT

A DISCUSSION OF transformer design and characteristics would have been a rather controversial subject 15 years ago, as in those days the name-plate kilovolt-ampere rating of the transformer meant little other than that it was printed in English. Oftentimes in the early years, if the power companies limited the maximum connected kilovolt-amperes for a particular installation, a machine was supplied with this name-plate kilovolt-ampere rating, regardless of the actual load drawn by the machine. It was rather common practice to use excessive amounts of copper in the secondaries and a very small amount of primary copper. There was no logical reason for this except perhaps that the secondaries could be seen while the primaries were covered. In general, confusion existed, no standard ratings were used, and it was extremely difficult for power companies or users to determine actual ratings and demand figures. This condition of course could not continue and several years ago the AIEE and the Resistance Welder Manufacturers' Association (RWMA) drew up specifications for the standardization of welding transformer ratings.

No attempt will be made here to discuss design procedures such as specific current densities, flux densities, and so forth, but rather to discuss the basis of transformer ratings and factors affecting the design as well as factors

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Full text of paper 53-296, "Design of Transformers for Resistance Welding Machines," recommended by the AIEE Committee on Electric Welding and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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which should be of primary interest to power companies and users of welding equipment.

BASIS OF TRANSFORMER RATINGS

The operation of a welding transformer differs from that of a conventional power transformer, in that the load on the power transformer is of a continuous nature, whereas the load on a welding transformer is a rapidly recurring one, usually approaching short-circuit values. In order to obtain a closer agreement between the actual instantaneous kilovolt-ampere demand and its kilovolt-ampere rating, it was decided to use a 50-per-cent duty-cycle rating rather than the normal 100-per-cent duty-cycle rating used for most other transformers. The 50-per-cent duty-cycle rating, maximum temperatures, conditions and methods of making temperature tests, were established by the AIEE and adopted by RWMA as standards.

The transformer design for resistance welding machines is discussed on the basis of ratings, construction, impedance, efficiency, excitation and core loss, types of secondaries, and insulating materials, and conclusions are presented.

These standards have eliminated much of the confusion that formerly existed, in that they definitely give a meaning to the name-plate rating. All resistance welding transformers manufactured today by members of the RWMA have a standard rating. The definition is: "The standard rating shall be the periodic rating based on a 50-per-cent duty cycle and a 1-minute integrating period." Name-plate rating does not necessarily indicate the maximum demand of the machine but definitely gives the thermal limitations of the transformer.

Some confusion still exists in interpreting the ambient temperature to be used in transformer tests. Because the transformers as a rule are water-cooled devices, it is generally agreed that the ambient temperature should be determined by the inlet-water temperature. This is now being considered by members of the RWMA, and the standards will be revised in this respect.

CONSTRUCTION

The shell-type core with interleaved pancake windings generally is considered the most suitable type of construction for a low-voltage high-current transformer. The most economical disposition of material is possible and the problems of bracing the coils to withstand the mechanical stress is accomplished more easily.

The primaries are usually pancake-wound with fully annealed rounded-edge copper strip varying in width and thickness depending upon the rating. The secondaries are single-turn pancake coils of cast rolled copper or copper tubing. The coils are assembled in a shell core with interlacing of the primary and secondaries.

A welding transformer must be able to withstand repeated overloads up to six times its rated capacity at reduced duty cycles. The mechanical stresses which are developed in the windings of the transformer under these conditions are many times higher than would be expected if the unit were operated at rated load. A problem is involved in bracing of the coils to prevent their injury under these operating conditions.

When the primary and secondary coils of a transformer winding are assembled, the currents in these two elements are opposite in direction. Due to the magnetic field present a force is set up which tends to separate the coils. For flat primary and secondary coils having the same over-all dimensions and identical electrical centers, the forces act in the direction shown in Figure 1*A*. The repelling forces are all at right angles to the plane of the coils. When the electrical centers are separated, however, as shown in Figure 1*B*, there is a component of force parallel to the planes of the coils as well as at right angles to them. This component may be quite large and sufficient to damage the coils by driving them apart. If the coils are concentric with reference to one another, but one having smaller dimensions than the other, the forces acting between the coils are shown in Figure 1*C*. In addition to repelling forces at right angles to the plane of the coils there are components parallel to these planes which tend to force the sides of the smaller coils inward and the sides of the larger coils outward. These forces may be sufficient to damage the coils and for this reason the coils should be made to conform as nearly as possible to the arrangement shown in Figure 1*A*. The force acting between coils may be a few pounds or several hundred depending upon the size of the transformer. The parts of the coils within the transformer are held so that movement cannot take place, while the ends outside the core are braced by plates forced against the coils by means of tie bolts or pressure screws in the core frames.

Impregnation of the coils is accomplished several ways by different manufacturers. Some impregnate the primary coils before assembly and do not dip the entire transformer. Others do not dip and bake the primaries before assembly, but assemble the transformer and impregnate as a unit. The others dip and bake the primaries before assembly, assemble, and then impregnate the entire transformer. The transformer should be dipped and baked as a unit. Whether the primary coils are impregnated before assembly depends on the penetration obtained at all points during the impregnation of the unit as a whole. Dipping and baking the entire transformer increases its oil and water resistance and also increases the efficienty of heat transfer by filling the voids.

TRANSFORMER IMPEDANCE

The impedance rating of transformers is defined by RWMA Standards as "The per cent impedance of the transformer shall be expressed in terms of per cent primary voltage required to force rated primary current through the combined resistance and reactance of the transformer proper. For this purpose the secondary windings shall be considered to consist of only that portion of the winding which is covered by the primary coils." In the past few years considerable effort has been expended to reduce transformer impedance as much as possible without penalizing the cost of construction. It is well to consider some

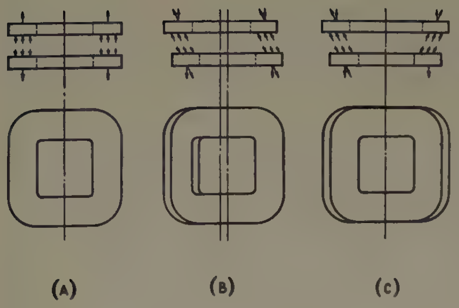


Figure 1. Forces between flat primary and secondary coils

A—Electrical centers in line; B—Electrical centers out of line; C—Electrical centers in line but coil of different dimensions

of the factors that affect transformer impedance. From the formula for inductance of flat pancake-type primary and secondary coils:

$$L=3.2\times T_1^2\times\frac{MT}{l}\left(s+\frac{d_1+d_2}{6}\right)10^{-8}$$

where

L = inductance in henrys
T_1 = turns in primary coil
MT = mean turn in inches
l = height of primary coil in inches
s = distance between primary and secondary coil in inches
d_1 = width of primary coil in inches
d_2 = width of secondary coil in inches

It can be seen that the following factors affect the transformer impedance:

1. Thickness of primary and secondary coils.
2. Space between primary and secondary coils.
3. Number of turns in the primary.
4. Mean length of turn.
5. Number of primary and secondary coils.

Present-day welding transformers generally use relatively more primary and secondary coils of thinner section and thinner insulation between coils, resulting in closer coupling between the primary and secondaries. The secondary of a welding transformer is inherently a 1- or 2-turn coil, hence the number of turns in the primary is a direct function of the secondary voltage required.

Little improvement can be made in the mean turn since it depends greatly on the cross-sectional area of core iron. Because the device is inherently a single-turn secondary transformer, the volts per turn are dependent entirely on the secondary voltage required, therefore the section of core iron is fixed.

What effect does transformer impedance have on the total impedance of the welder? Figure 2 shows the relationship between transformer impedance and total impedance for various loop or throat areas when a transformer of 30-micro-ohm total impedance (referred to the secondary) is connected to various loops. The curve is not a straight line because the power factor of the loop changes as the throat area increases, while the transformer power factor remains the same. It is apparent that the effect of the transformer impedance on the over-all impedance becomes decreasingly less as the throat area increases.

In comparing per cent impedance of transformers with the same kilovolt-ampere rating, it is necessary that the turn ratio be considered, when considering their effect on over-all welder impedance. Although the per cent impedance may be the same, the transformer impedance in ohms referred to the secondary will be different if the turn ratios are not the same.

Example 1 illustrates two transformers with the same kilovolt-ampere rating and per cent impedance, but with slightly different secondary voltages and turn ratio. The impedance referred to the secondary in one case is 94.5 micro-ohms while the other is only 79.2 micro-ohms. If these transformers are connected to the same secondary loop, the maximum secondary current will be approximately the same despite the fact that one secondary voltage is lower than the other.

Example 1. Relationship between per cent impedance and turn ratio.

Conditions: Assume both transformers connected to the same loop area and configuration.

Loop Values

Impedance = 0.0001 ohm
Power factor = 40 per cent
Resistance = 0.00004 ohm
Reactance = 0.0000916 ohm

Transformer Number 1

Kilovolt-ampere = 50 name plate
Per cent impedance = 10 per cent
Primary impedance = 0.388 ohm
Power factor = 70 per cent
Turn ratio = 64
Secondary impedance = 0.0000945 ohm
Secondary resistance = 0.0000662 ohm
Secondary reactance = 0.0000676 ohm
R_s (total loop and transformer) = 0.0001062 ohm
X_s (total loop and transformer) = 0.000159 ohm
Z_s (total loop and transformer) = 0.000191 ohm
Maximum secondary current = 35,900 amperes
Kilovolt-ampere = 247

Transformer Number 2

Kilovolt-ampere = 50 name plate
Per cent impedance = 10 per cent
Primary impedance = 0.388 ohm
Power factor = 70 per cent
Turn ratio = 70
Secondary impedance = 0.0000792 ohm
Secondary resistance = 0.0000555 ohm
Secondary reactance = 0.0000566 ohm
R_s (total loop and transformer) = 0.0000955 ohm
X_s (total loop and transformer) = 0.000148 ohm
Z_s (total loop and transformer) = 0.000176 ohm
Maximum secondary current = 35,700 amperes
Kilovolt-ampere = 224

The transformer impedance is very important with low load impedance while it assumes less importance as the load impedance increases. However this does not mean that the per cent impedance of the transformer should not be kept at a minimum regardless of the load impedance for which it is designed. Usually in welding machines the transformer is designed for a given secondary loop or load impedance. In any kilovolt-ampere size the maximum secondary voltage (turn ratio) is changed for appreciable differences in throat depth or configuration. The intent is to maintain approximately the same maximum kilovolt-ampere demand regardless of the load impedance. Under these conditions a change in per cent impedance of a transformer designed for a high load impedance will cause the same percentage change in output, as an equal change in per cent impedance of a transformer designed for low load impedance.

Another factor that influences the effect of transformer impedance on the total impedance, is the power factor of the transformer. Although the per cent impedance may be the same, if the power factor or ratio of R and X in the transformer changes, the effect on the over-all impedance will change.

Figure 3 is a curve showing the change in total impedance with varying transformer power factors using constant loop impedance and constant per cent transformer impedance.

TRANSFORMER EFFICIENCY

Distribution transformers are designed for a very high light load efficiency, because they are permanently connected to the power lines. On the other hand, welding transformers are energized only a small fraction of the time. If a machine operates on a duty cycle of 5 per cent for 8 hours a day, 5 days a week, it is only on the line 2 hours per week as compared to 168 hours for a distribution transformer. Losses, therefore, in a welding transformer assume minor importance while impedance, space, weight, cost, and mechanical construction assume major importance. It is not intended to imply that efficiency is not to be considered, however these other factors are more important and high efficiency must not be secured at their expense.

More important to the welder user and power company is a "welder efficiency" which could be defined as "the ratio of secondary ampere output to kilovolt-ampere input." In other words "welding amperes per kilovolt-ampere input." Welding with its high intermittent load often presents difficult power supply problems, therefore any design change that increases the "welder efficiency" simplifies the power problem and results in a more economical installation. As shown previously, proper transformer design can increase "welder efficiency."

EXCITATION AND CORE LOSS

Distribution transformers are permanently connected to the power company lines and it is important that excitation current and no-load losses be kept to a minimum. Since welding transformers never are operated at no load under normal conditions, the excitation current and no-load losses are of no consideration except as they affect the normal load current, performance, and over-all power factor.

With the importance of compactness and weight, the tendency is to work the core iron at higher densities than would be used for distribution transformers. The RWMA standards have specified the maximum exciting current as follows: not to exceed 10 per cent for transformers up to 100 kva and not to exceed 5 per cent for all transformers 100 kva and over. These values would not be tolerated in a distribution transformer, but they represent practical limitations for welding transformers.

In general, shell-type cores are used, except in the smaller kilovolt-ampere sizes. Using the shell-type core, adequate bracing to withstand the mechanical stresses involved during the momentary overloads are easier and more economically accomplished.

What type of electrical steel is best for welding transformers? The important limitation for core design is not core losses but is the excitation or no-load current. Although it is not necessary to keep the excitation current to a low value as is required in power or distribution transformers, the excitation current must be low enough so that it does not seriously affect the normal load current, performance, and over-all power factor. The standards set up by the RWMA do meet this requirement. In order to keep the core section to a minimum, the designer requires a core material with as high a permeability as possible at high induction. Where space is not too important a consideration, the choice of electrical sheet is a matter of economics. The designer must balance the cost of the core material against increased size and weight of the transformer, to determine the most economical construction.

In the past few years a considerable number of welding transformers have been built using special type of core material. Special cores are made from high-quality cold-rolled silicon steel with preferred crystal orientation. This preferred orientation results in very low losses and low excitation current in the direction of rolling. With the preferred orientation of the crystals, the knee of the satura-

Figure 2. Relationship between transformer impedance and total impedance

Transformer $Z_s = 30$ *micro-ohms; Power factor = 80 per cent*

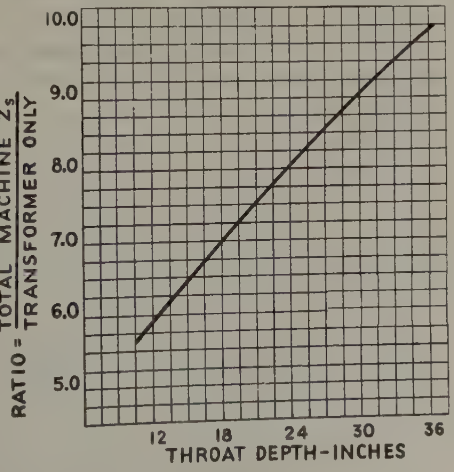
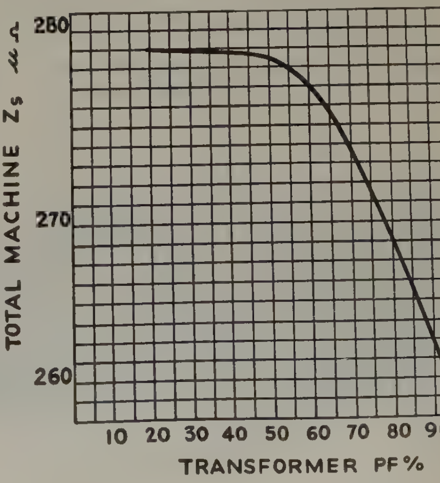


Figure 3. Change in total impedance with varying transformer power factors

100 air-operated press-type 18-inch Z_s *= constant-loop only; Transformers per cent* Z *= constant = 10 per cent; Loop* $Z = 180$ *micro-ohms*



tion curve is raised so that the core can be operated at at least 30 per cent higher flux density with the same magnetizing force or excitation current. A comparison of the saturation curves for the special cores and high-grade silicon steel laminations is shown in Figure 4. The increased flux densities result in transformers smaller in over-all size and weight. It is this factor and this factor alone, that to date chiefly has determined the use of special core iron for welding transformers. Figures 5 and 6 show welding transformers manufactured with these cores. Figure 5 is a 35-kva 2-secondary unit used in multitransformer welders where space is limited. Without the use of special core iron with high permeability at high induction it would be impossible to obtain a transformer of this rating in the space allowed. Figure 6 is a standard 100-kva 50-per-cent duty cycle transformer for a pedestal-type welder. The cubic space occupied by this unit is approximately 75 per cent of that necessary if standard high-grade electrical laminations were used.

The question may be raised as to why not all welding transformers are made with special high-permeability high-induction cores. Here again it is a matter of economics. The cost per pound of the core material is considerably higher and the designer must balance this cost against the saving in all material due to the decreased size and weight, and the labor saving involved in shearing and stacking standard laminations.

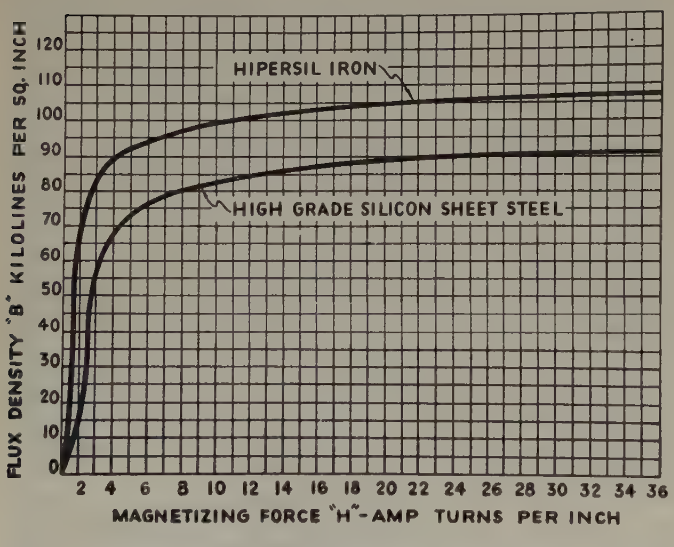


Figure 4. Comparison of the saturation curves for the special cores and high-grade silicon-steel laminations

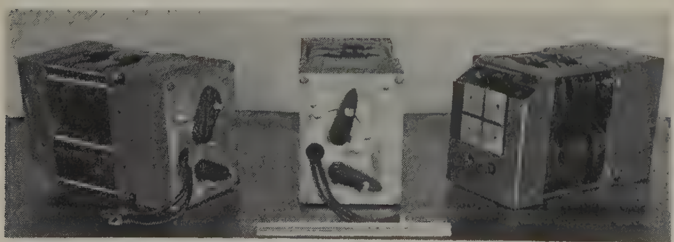


Figure 5. Two-secondary special-core-iron 35-kva welding transformer

TYPES OF SECONDARIES

The secondary of a welding transformer is a high-current low-voltage winding carrying instantaneous currents sometimes in excess of 200,000 amperes. Except in the very small sizes, the high currents make it necessary to have large cross-sectional areas of copper. To reduce their size by working at higher current densities they are usually water cooled. At the same time the primaries are cooled by conduction of the heat to the secondaries.

Numerous types of secondaries have been used in welding transformers. For the purpose of this article, the four major types used today as shown schematically in Figure 7 will be discussed.

Number *1* is a cast copper secondary with cast-in water cooling tubes. This type is the one most commonly used today. The cost of construction is low and efficient cooling is obtained with the cast-in water cooling tubes. One distinct advantage of this type is the ability to obtain difficult secondary snout or terminal connecting pads without increasing the cost appreciably. In order to cast in water cooling tubes of sufficient area, the minimum width of the secondary is limited to approximately 5/8 inch. This is a disadvantage where transformer impedance is important. Another disadvantage is the relatively low conductivity of the cast copper and the inability to obtain uniform conductivity unless the foundry practice is very closely controlled.

Number *2* is a cast copper secondary with brazed-on water cooling tubes. This type of construction allows the use of thinner secondary sections making it possible to decrease the impedance of the transformer. It also eliminates the porosity sometimes experienced in casting internal water cooling tubes. The cooling tubes sometimes collapse during the casting operation, resulting in a defective casting. Tests indicate however that the cooling is usually not as efficient as obtained with cast-in cooling tubes.

Number *3* is a secondary fabricated from rolled copper plate with water cooling tubes brazed to the fabricated assembly. Electrolytic rolled copper having a greater conductivity than cast copper, permits higher current densities to be used resulting in reduced copper section and size. The smoother surface of the rolled copper secondary results in a lower thermal gradient between the primary and the secondary windings. The higher allowable current densities decrease the over-all size of the transformer. This type of construction also allows the designer to use thinner sections for reduced transformer impedance. The most serious disadvantage is the increased cost of construction.

Number *4* is a secondary fabricated from copper tubing. Round copper tubing is bent and formed to a rectangular section by a special process. The efficiency of cooling is superior to any of the other types and permits the use of much higher current densities. This type of construction is difficult to manufacture. Minimum radii must be maintained at the bends resulting in definite limitations to the designer. Because of the much higher current densities used and the smaller section of copper, the unit has relatively low thermal inertia. In other words, the transformer would reach dangerously high operating temperatures in a much shorter time if the cooling water were lost momentarily.

To state definitely which secondary construction is best would be extremely difficult and would lead to an endless argument. All have advantages and disadvantages. Which is used depends on the application, cost, preferences of the individual designer, and available manufacturing facilities.

INSULATING MATERIALS

In welding transformers the insulating problems are similar to those found in other low-voltage types. The primary and secondaries must be adequately insulated from each other and both insulated from the core. In general the practice today is to use Class *B* insulation throughout, except in some cases a small amount of Class *A* insulation is used for mechanical purposes. The insulating materials should be oil and water resistant at the operating temperatures used. One of the problems confronting the designer is water condensation. In highly humid weather, if the machine is operated at a reduced capacity, considerable condensation may occur on the secondaries. If this condition exists over prolonged periods, failure may occur if the insulating materials do not have good water-resistant characteristics. Even then under prolonged periods of condensation it is difficult to prevent insulating failures. The transformers are often used on hydraulic machines and despite all precautions leaks will occur. Therefore the insulating material also should be oil resistant.

In large welding transformers the volts per turn seldom exceed 30 volts, thus presenting no difficult insulating problem. Usually mica plate or varnished glass cloth is used. Sometimes the insulating material used is cut slightly wider than the width of the primary copper. This however has a disadvantage in that the efficiency of heat transfer between primary and secondary coils is reduced.

The ideal barrier material between primary and secondaries would be one with high dielectric and mechanical strength, and high thermal conductivity. Unfortunately insulating materials with high dielectric strength have relatively low thermal conductivity. Laminated phenolic material or varnished glass cloth are most widely used as a barrier.

In the past few years some work has been done with silicone insulating materials. These materials can be operated at much higher temperatures than can be used safely with other materials. Experimental units have been built and operated at temperatures exceeding 350 degrees Fahrenheit. The material offers much promise for the future but at present it is difficult to justify the high cost, unless unusual operating conditions are encountered.

CONCLUSIONS

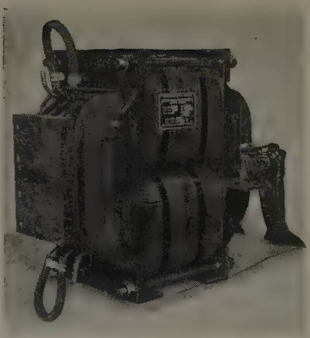
1. AIEE-RWMA standards for transformer ratings have gone a long way in eliminating the confusion that existed before the standards were adopted.

2. The importance of transformer impedance decreases as the throat area (or load impedance) increases.

3. Losses in a welding transformer assume minor importance as other factors are more important and high efficiency must not be secured at their expense. More important is welder efficiency (secondary amperes versus kilovolt-ampere input).

4. The excitation current is of no consideration, except as it affects the normal load current, performance, and over-all power factor.

5. Major improvements have been made in the performance of welding transformers in the past 20 years and reliable information on operating characteristics is now available.



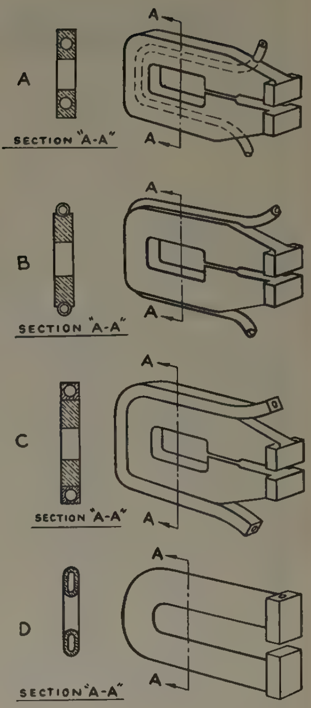


Figure 6 (above). Standard 100-kva special core welding transformer with rolled copper secondaries. Figure 7 (right). Types of secondaries used in welding transformers

A—Cast copper water cooling internal; B—Cast copper with water cooling tube brazed; C—Fabricated secondary; D—Copper tubing

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Highest Head Propeller Turbines

The Washington Water Power Company's Cabinet Gorge hydroelectric plant has the highest head installation of propeller-type turbines in the United States and has the longest penstocks ever used with this type of turbine. They are 600 feet long and are not equipped with surge tanks.

The installation consists of four propeller turbines rated 70,500 horsepower, 120 rpm, under 90 feet effective head. Maximum head will be 105 feet at which the turbines will develop 85,000 horsepower. Three are fixed-blade propeller-type turbines and the fourth has an adjustable-blade runner. The latter type will handle the system load swings; the fixed-blade types operate on base load.

Maintenance of Transmission Lines by Helicopter

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SUCCESSFUL USE of the transport helicopter in Korea and in the Canadian Rockies of British Columbia is focusing attention on the potentialities of this craft as a transport vehicle. With such successful operations in mind, a study was indicated of the feasibility of using a commercially available 8-passenger 1,500-pound payload-carrying transport helicopter for transmission-line maintenance and repair work. The system studied was the 1,558-mile transmission system of the Parker-Davis Project of the Bureau of Reclamation, in Arizona, California, and Nevada.

Figure 1 shows the payload-carrying capabilities of the transport helicopter under varying conditions of operation when equipped with suggested basic optional items. Line crews, tools, and supplies for hot line change-out of a 230-kv insulator string will weigh approximately 1,400 pounds; a 161-kv double crossarm change-out, about 2,600 pounds; a conductor break for either voltage, about 2,700 pounds. A special cross-country vehicle would be used for pole and tower replacement. A comparison of these weights with Figure 1 shows the transport helicopter to be capable of expeditiously transporting, in one load, crews and equipment necessary to accomplish satisfactorily usual transmission-line repair work. Two trips are necessary in the less frequent instances of crossarm change-out and conductor breaks for high-voltage lines.

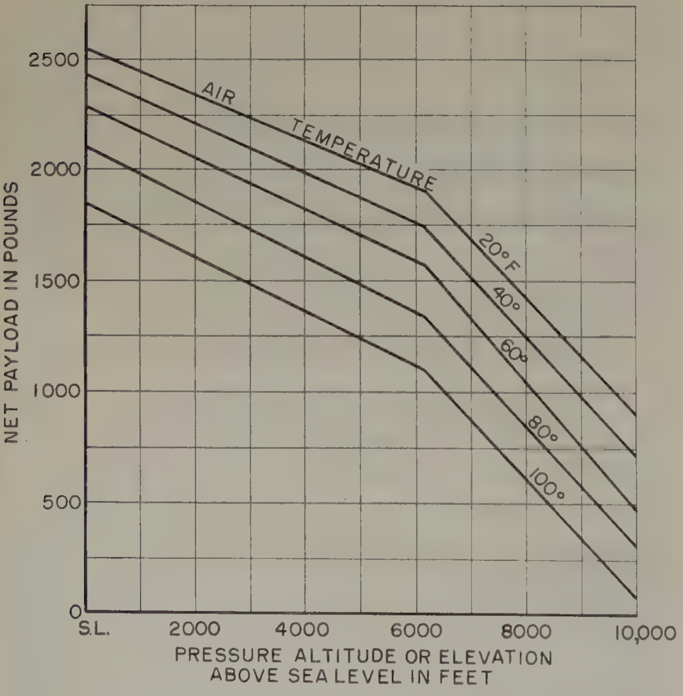

Figure 1. Payload capacity in pounds for vertical take-off performance of Sikorsky S-55 helicopter. No wind, no ground run, and ability to clear 50-foot obstacle in 400 to 500 feet. Take-off weight less payload, 5,450 pounds

Table I. Comparison of Annual Maintenance and Repair Expenses—1,558-Mile Transmission System—Parker-Davis Project

Estimated expenses using light helicopter for patrol, with conventional maintenance and repair methods—for year 1955	
Salaries	$223,000
Travel expense	24,000
Equipment use	30,000
Patrol helicopter*	18,000
Patrol road maintenance	50,000
Estimated annual expense	$345,000
Estimated expenses using two transport helicopters as major transport medium for transmission line patrol, maintenance, and repair—for year 1955	
Salaries	$133,400
Travel expense	4,000
Equipment use	20,000
Transport helicopters†	112,600
Patrol road maintenance	16,000
Estimated annual expense	$286,000
Estimated annual saving	$ 59,000

* All operating expenses, including salaries of pilot and mechanic.

† All operating expenses, including salaries of three pilots and three mechanics.

For the system under study, using two transport helicopters permitted:

1. Reduction of five line crews to two main crews and an auxiliary crew.
2. Virtual elimination of patrol roads for steel tower lines and reduction of requirements for wood-pole lines.
3. Taking advantage of helicopter's mobility in the strategic location of line crews for service restoration during emergent conditions.

Patrolling would be accomplished by helicopters. Preventive maintenance of steel tower lines would be incorporated in the patrol activity. Ground vehicles would be used for preventive maintenance of wood-pole lines with vehicles remaining in work area. Helicopters would transport all men, supplies, and fuel to daily work sites. In addition to providing satisfactory maintenance and repair transportation and making possible quicker restoration of service during emergent conditions, the entire job can be accomplished at a considerably reduced annual cost, as is shown in Table I.

This study indicates that for the system studied the use of the transport helicopter takes advantage of the inherent qualities of this type of craft and capitalizes on its ability to carry repairmen, tools, and supplies to work areas in minutes, rather than hours, as is required now. The transport helicopter's relatively great speed and mobility make possible a major reduction in maintenance crews and equipment; increased continuity of service; a substantial saving in maintenance and repair costs; and an inherent improvement in customer service.

Digest of paper **53-341**, "Economics of Transmission-Line Maintenance and Repair by Helicopter," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Resistance Bridge Sensitivity and Output Formulas

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CONVENIENT FORMULAS for current and voltage in the detector branch of a resistance bridge are shown in Figures 1 to 3. These formulas are particularly useful for determining either the exact sensitivity of the balanced bridge or the approximate output of the unbalanced bridge where the unbalance is, in general, not greater than the order of 10 per cent. In either case, the user is assumed to be referring to and working from the balanced-bridge condition. The proportional error of the output approximation, based on the exact output value, does not exceed the proportional unbalance of the bridge (for example, no more than a 1-per-cent error results if the bridge is out of balance by 1 per cent). It does not matter whether the values of V, I, C, T, S, and D are taken from the balanced or from the unbalanced bridge, although it is more convenient to take them from the former. The formulas in Figure 3 are of course not new, being merely representations of Thevenin's Theorem, but they nonetheless belong in this group to complete the logical assembly of formulas.

$$e=\frac{VCp}{T}=\frac{I_p}{S}$$

Special case: where the voltage drop across all four arms is the same, then:

$$e=\frac{Vp}{4}$$

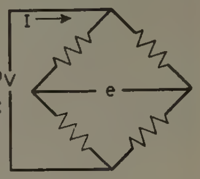

Figure 1. Available electromotive force (e)

V—input voltage across bridge
C—output resistance across bridge
p—proportional unbalance
T—sum of resistances of all four arms
I—input current to bridge
S—sum of conductances of all four arms

$$i=\frac{Vp}{T}=\frac{IDp}{T}$$

Special case: if the current through all four arms is the same, then: $i=\frac{Ip}{4}$

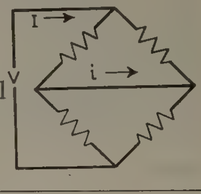

Figure 2. Available current (i)

D—input resistance across bridge

$$i_G=\frac{e}{G+C}=\frac{iC}{G+C}$$

Special case: if the resistance of all four arms is the same, then C = the resistance of one arm

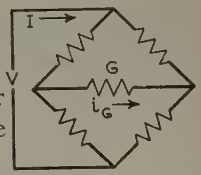

Figure 3. Current (i_G) in output branch

G—resistance of output branch

The proportional unbalance of the bridge is defined as the proportional change of resistance in one arm to produce the unbalance. For example, if one arm of a balanced bridge, that is a bridge in which the four arms form a direct proportion, has a resistance of 100 ohms, then an increase (or a decrease) of 5 ohms in this arm will produce an unbalance of 5 per cent (or $p=0.05$).

A more general definition of proportional unbalance (p) is as follows: If X, A, B, and R represent the resistances of the four arms of the balanced bridge in rotation, that is, $A/B=X/R$, and if the change occurs in one or more of the arms, the proportional changes being represented by the expressions $\Delta X/X$, $\Delta A/A$, $\Delta B/B$, $\Delta R/R$, then p is represented by the algebraic sum of the proportional changes with alternating signs, that is, $p=+\Delta X/X-\Delta A/A+\Delta B/B-\Delta R/R$; signs being taken as shown or reversed depending whether the term represents an increase or decrease respectively.

To obtain exact outputs for substantial unbalances, a correction factor may be multiplied by any of these formulas. This factor, where V, I, C, T, S, and D are taken from the balanced bridge, where $p = \Delta X/X$ with appropriate sign, where L = resistance of the input branch, and where the output terminals are the junction of X and R and the junction of A and B is $1/(1+pz)$ where $z=[X+R/(1+G/C)+A/(1+L/D)]/T$. Special cases: in applying to formulas for e (Figure 1), $G=\infty$; to formulas for i (Figure 2), $G=0$; if V represents the voltage across the unbalanced bridge, $L=0$; if I represents the current to the unbalanced bridge, $L=\infty$.

There are, of course, two possible locations of the detector branch in the bridge circuit. In general, the preferred location is the one for which the resistance of the bridge is nearer to the external resistance specified for the detector. However, by "nearer" is meant nearer by ratio and not nearer by arithmetic difference. Where there is some doubt as to the correct choice and where the wattage limitation is the same for all four arms, the following rule applies: "Connect the detector across the higher or the lower bridge resistance depending upon whether the specified external resistance of the detector is higher or lower respectively than the geometeric mean between the resistances of either pair of opposite arms." The branch which connects the junction of the two lowest resistance arms with the junction of the two highest resistance arms is across the higher bridge resistance.

Digest of paper **53-1**, "Sensitivity and Output Formulas for the Resistance Bridge," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Economic Thermal-Hydroelectric System Operation

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THE THEORY and practice involved in the economic scheduling of thermal plants, including the effects of transmission losses, has been well developed in recent years. This article presents a method for short-range optimum economic scheduling of a thermal-hydroelectric power system with transmission losses rigorously considered.

The optimum scheduling problem as considered here is defined as follows: When using desired amounts of water from the hydroelectric plants over a given period of time, it is desired to minimize the total fuel input in dollars.

If it is assumed that, for the period of time under consideration, the hydroelectric plants operate at essentially constant head, the co-ordination equations whose solution gives the optimum schedule are

$$\frac{dF_n}{dP_{Sn}}+\lambda\frac{\partial L_T}{\partial P_{Sn}}=\lambda \qquad n=1,\ 2,\ \ldots.\alpha \qquad (1)$$

$$\gamma_j\frac{dW_j}{dP_{Hj}}+\lambda\frac{\partial L_T}{\partial P_{Hj}}=\lambda \qquad j=\alpha+1,\ \alpha+2,\ \ldots.\beta \qquad (2)$$

where

$\frac{dF_n}{dP_{Sn}}$ = incremental fuel cost of thermal plant n in dollars per megawatt-hour

$\frac{\partial L_T}{\partial P_{Sn}}$ = incremental transmission loss of thermal plant n

$\frac{dW_j}{dP_{Hj}}$ = incremental water rate at hydroelectric plant j in feet^3 per megawatt-hour

$\frac{\partial L_T}{\partial P_{Hj}}$ = incremental transmission loss of hydroelectric plant j

λ = incremental cost of received power in dollars per megawatt-hour

The conversion coefficients, γ_j, which effectively convert incremental water rates into incremental plant costs determine the amount of water used at each hydroelectric plant.

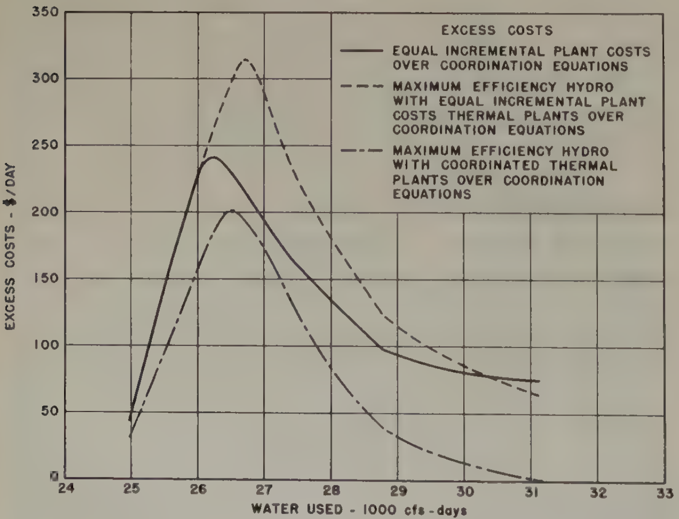

Figure 1. Excess costs of other methods over co-ordination equations scheduling

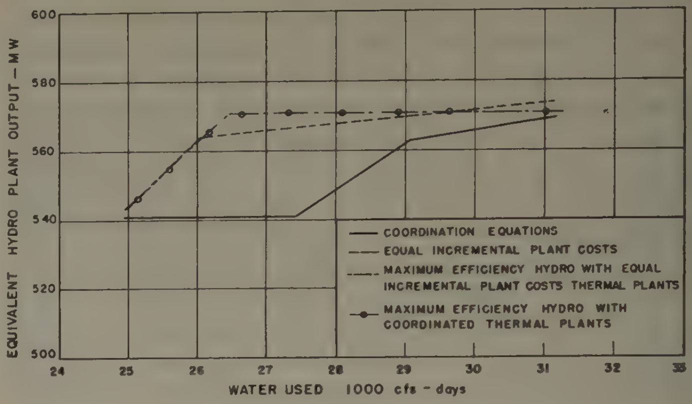

Figure 2. On-peak hydroelectric generation schedules

For purposes of making an economic comparison of various methods of scheduling generation, the 17-variable loss formula for the Southern Ontario 60-cycle system of the Hydro-Electric Power Commission of Ontario was reduced to a 4-variable formula including the two major steam plants on the system and one equivalent hydroelectric plant, with the fourth variable consisting of the other generation of the system. The following methods of scheduling the hydro plant and the two thermal plants were then compared: 1. Co-ordination equations (use of equations 1 and 2). 2. Equal incremental plant costs (use of equations 1 and 2 with $\partial L_r/\partial P$ terms considered zero). 3. Maximum efficiency hydroelectric (hydroelectric plant operated at the point of maximum efficiency). (*a*). With thermal plants scheduled according to co-ordination equations. (*b*). With thermal plants scheduled at equal incremental plant costs.

The results shown in Figure 1 and Figure 2 indicate the advisability of operating the hydroelectric plants below the point of maximum efficiency as a first step toward economic system operation of the hydroelectric plants except when surplus water is available. This is a specific conclusion for the system studied, but, in general, will be advisable for hydroelectric plants where long distances from loads are involved.

Some additional problems requiring fundamental investigation are effect of head variation, time of flow between plants, probability of occurrence of flows, and manipulation of annual storages.

Digest of paper 53-326, "Short-Range Economic Operation of a Combined Thermal and Hydroelectric Power System," recommended by the AIEE Committees on Transmission and Distribution and System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Magnetic Amplifier Performs Analytical Operations

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THE CIRCUIT shown contains two saturable reactors with "square loop" cores. An alternating voltage is applied to their windings through rectifying diodes. During positive half-cycles of the supply voltage V_{gc} the core flux of the converter stage rises from some preset value to saturation. Before "firing" only a small magnetizing current flows; after firing the supply voltage appears across the load resistance R_c and the winding resistance r_c. The preset flux is determined jointly by the line voltage, which in negative (presetting) half-cycles tries to remove the core from positive saturation and by the opposing voltage of a given half-wave sinusoidal signal V_{s1}.[1] This stage converts the waveform of the signal V_{s1} into a net output waveform V_c' of nearly equal half-cyclic area.

The multiplier stage operates in a similar way as it proceeds toward saturation and eventually fires. Its presetting, however, is controlled by two inputs, namely by V_c' and by another given half-wave sinusoidal signal V_{s2}. The multiplier core is removed from saturation by the difference between the a-c supply voltage and whichever voltage V_c' or V_{s2} happens to be the lower. A_V is the volt-time area of reset which determines (and equals) the prefiring area A_{VII}. The output voltage V_M therefore has a volt-time area A_{VIII} equal to the area A_{VI} of the "contour of least ordinates" defined by the two curves V_c' and V_{s2}. The reading V_M of a d-c voltmeter across R_M is proportional to the cyclic averages V_1 and V_2 of the two signal voltages V_{s1} and V_{s2} and is inversely proportional to the a-c supply voltage V_{gc}. Thus multiplication as well as division of voltages is performed. Other analytical operations are performed also by similar techniques with extreme simplicity of components and accuracy adequate for many practical applications.

REFERENCE

1. Methods of Magnetic Amplifier Analysis, **L. A. Finzi, G. F. Pittman, Jr.** *Electrical Engineering*, August 1953, pages 690–4.

Digest of paper 53-285, "An Application of Magnetic Amplifier Circuits to Perform Multiplication and Other Analytical Operations," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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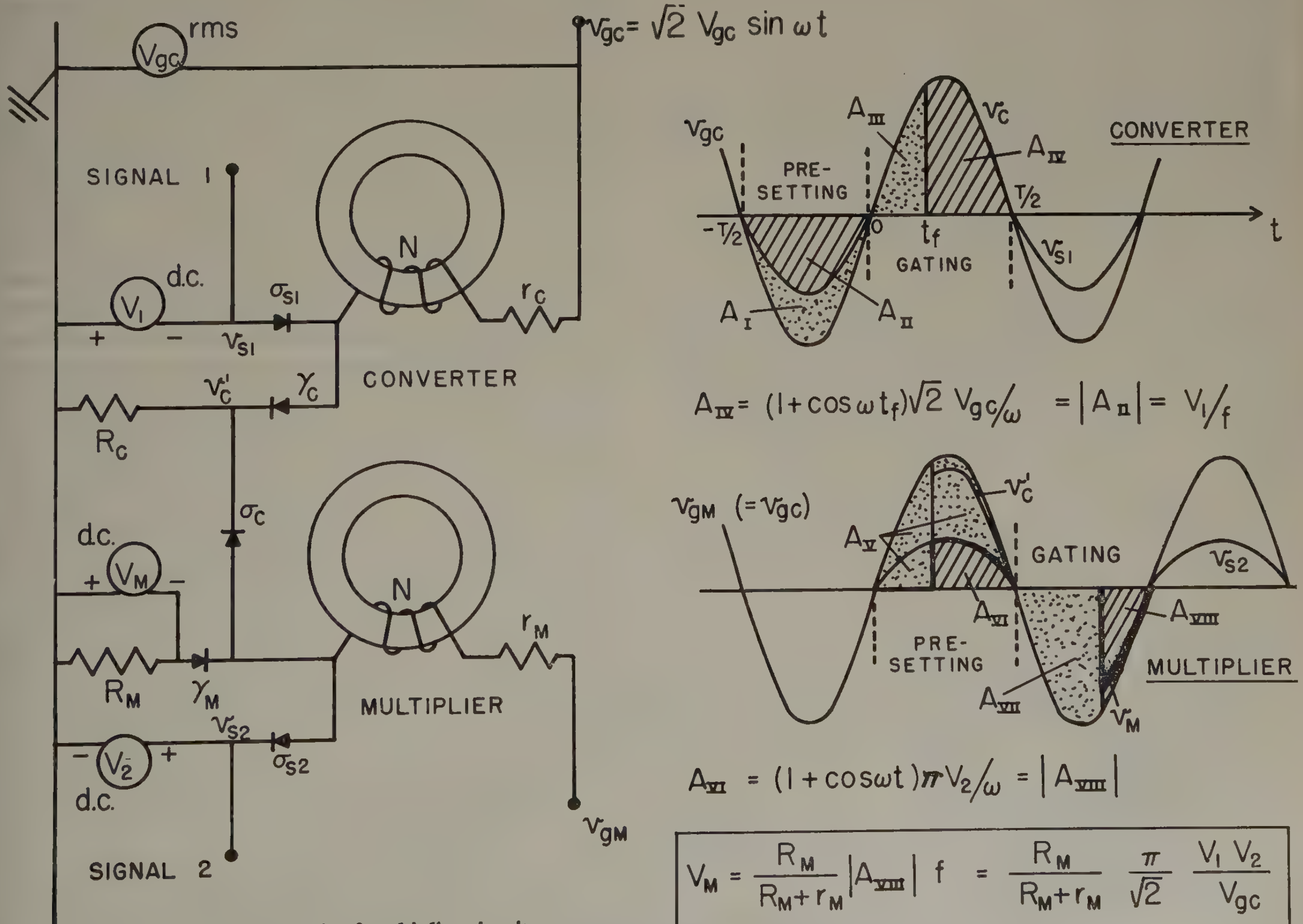

Figure 1. Example of multiplier circuit

System Grounding in Industrial Plants

F. M. DOREY
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Some of the reasons why grounding is important are discussed together with various methods for satisfactory neutral grounding of 3-phase a-c systems in industrial plants.

THE QUESTION OF electric system grounding in industrial plants is one that should be considered not only on new plant installations and on modernization of existing plant facilities, but also should be considered with respect to operating existing plant electric systems that were designed originally for ungrounded operation.

NATURE AND CAUSE OF OVERVOLTAGES

THE SOURCES of overvoltages are many and of varied character. The most prominent ones include:

1. Lightning.
2. Static.
3. Physical contact with a higher voltage system.
4. Switching surges.
5. Resonance effects in series inductive-capacitive circuits.
6. Repetitive restrike (intermittent grounds).

Much has been written concerning overvoltage due to reasons 1, 2, 3, and 4 and the beneficial results obtainable when the system is operated as a grounded system. The scope of this article will be limited to reasons 5 and 6.

RESONANT EFFECTS IN SERIES INDUCTIVE-CAPACITIVE CIRCUITS

UNGROUNDED NEUTRAL a-c systems are most commonly subject to overvoltages originating from this cause. It is important to recognize that ungrounded neutral systems are actually capacitively coupled to ground rather than truly divorced from ground. Such systems are ungrounded in the sense that no interconnection with ground has been made purposely, but every element of the electric system incorporates some capacitance to ground which constitutes an inherent capacitive impedance interconnection between the electric system conductors and ground.

Every ungrounded electric system contains the essential elements presented in the lower diagram of Figure 1.

The electrical behavior of any 1-phase conductor relative to ground can be determined by a much simpler equivalent circuit as indicated in the upper sketch of Figure 1. In terms of this simpler equivalent circuit, it will be possible to understand readily the effect of connecting different types of impedance between line and ground as portrayed in Figure 2. It becomes evident that the connection of any value of either resistance or capacitance between one line and ground produces no dangerous overvoltages. The potential on the phase to which the impedance is connected progressively diminishes from normal value to zero. The potential to ground on the remaining two phase conductors will be increased to full line-to-line value at the time the first phase conductor has been reduced to zero potential. This represents an overvoltage of only 73 per cent which is not dangerously high and normally will produce no ill effect unless continued for a long time.

The connection of an inductive reactance between line and ground, on the other hand, can be responsible for the production of serious overvoltages to ground. It is the ratio of the inductive reactance of the line-to-ground circuit to the total capacitive reactance of the system to ground which controls the degree of overvoltage. The highest overvoltage will occur when these two reactances are equal and at this point may be as much as 10 to 20 times normal. It is significant to note, however, that over a two to one range of reactance, overvoltages of three times normal or more would be produced.

The unintentional connection of an inductive reactance between a phase conductor and ground can occur in a number of ways, some of which are illustrated in Figure 3. The operating magnetic coil of a motor-starter contactor may be connected inadvertently between phase and ground by a ground fault in the control wire to the push-button station or the slip of a maintenance man's screw driver. Any time that the inductive reactance value, which becomes connected from phase to ground, falls in the danger region indicated on Figure 2, dangerous overvoltages to ground will be produced which are communicated over the entire metallic conductor system of that operating voltage.

Overvoltages originating from this cause can be suppressed completely by a relatively light resistance ground on the electric system neutral. A grounding resistor of about the same ohmic value as the total charging capacitive reactance to ground eliminates overvoltages almost completely. It will be evident that there is good reason to adopt electric system neutral grounding with a much lower value of grounding resistance for other considerations.

INTERMITTENT GROUND FAULTS

SUBSTANTIAL OVERVOLTAGES can be developed in ungrounded a-c industrial systems by sputtering or

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intermittent ground faulting connections. The intermittent character of the fault path may be the result of vibration which causes an electric conductor intermittently to make contact with ground; the result of scattering particles of molten conductor metal which intermittently establishes a conducting path to ground; or as a result of successive breakdown and seal-off of the separating space between conductor and ground. In the last case involving a fixed separation between conductor and ground, a progressively increasing breakdown voltage across this gap is an essential element involved in the build-up of severe overvoltages.

Intermittent ground fault conditions on low-voltage ungrounded neutral systems have been observed to create overvoltages of five or six times normal quite commonly. An unusual case involved a 480-volt ungrounded system of a West Coast industrial plant. Line-to-ground potentials in excess of 1,200 volts were measured on a test voltmeter. The source of trouble was finally traced to an intermittent ground fault in a motor-starting autotransformer. About 2 hours elapsed while the source was being located during which time between 40 and 50 motors broke down.

Electric systems which are grounded through reactance of too high an ohmic value (X_0 more than ten times X_1) also are subject to overvoltage by this same mechanism acting in a little different form.

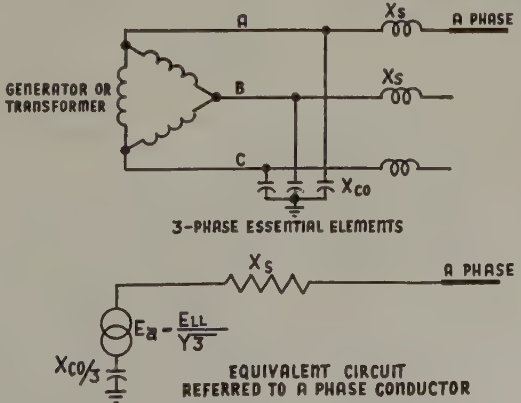
An understanding of the manner in which a discontinuous electric connection can be responsible for the generation of overvoltages can be acquired most easily by examining the case of a sputtering or intermittent line-to-ground fault on an ungrounded neutral system.

At *A* in Figure 4 the vector voltage pattern of a 3-phase a-c system is shown as it normally would operate under balanced unfaulted conditions. The voltage vectors $\mathbf{E}_a$, $\mathbf{E}_b$, and $\mathbf{E}_c$ rotate about the neutral at synchronous speed. The electric neutral is a point of central symmetry and remains constant at ground potential if the individual phase voltages are pure fundamental-frequency sine waves.

Should the *A* phase conductor become grounded the system voltage triangle would become displaced as illustrated in *B*. At the phase position illustrated in *B*, the *A* phase voltage is at its maximum value at which instant the charging current to ground is passing through zero. In case the fault circuit contains a small gap or an arc, the arc current would become extinguished at this point. Note that the trapped charge on the line-to-ground capacitance will tend to maintain the voltage triangle in the same displaced position. In other words, the potential of the neutral would tend to remain at a direct potential equal to the crest value of the a-c wave relative to ground. All of this merely says that there will be little tendency for any voltage to reappear across the gap in the ground fault circuit immediately following the current zero which occurs at *B*.

During the next half-cycle, however, the a-c generated voltages will reverse their polarities (vectors rotate 180 degrees) which would cause the 3-phase voltage vector pattern to assume the position shown in the upper part of *C*. Note that during this $^1/_2$-cycle time interval, the potential of the *A* phase has increased progressively from zero value to about twice the normal line-to-neutral crest voltage relative to ground potential. This value of line-to-ground potential of the *A* phase may be sufficient to break down the gap in the ground fault circuit and re-establish the connection between the *A* phase and ground. If so, the *A* phase potential will tend to be yanked suddenly to ground potential. There inevitably will be some system reactance in the *A* phase conductor to the ground fault point which would result in an oscillation of the *A* phase conductor potential between plus and minus two at a frequency probably 20 to 100 times normal. If the fault circuit consisted of a solid metallic connection, this oscillation would decay to zero leaving the *A* phase conductor at ground potential. Note that associated with this high-frequency transitory oscillation there will be associated a corresponding transitory charging current to ground. This transitory charging current to ground, or restrike current, again will reach zero value when the system voltage triangle is at the maximum excursion in the negative direction as shown in the lower part of *C*. Thus, an opportunity is afforded for the gap in the ground fault circuit to reclear. If reclearing does occur, a charge again is trapped on the system capacitance to ground which would tend to maintain a constant direct potential to ground on the system neutral.

In the course of the next following half-cycle, the voltage vector system again will rotate 180 degrees causing the potential of the *A* phase conductor to ground to be elevated from minus two to minus four as indicated by the transition from the lower part of *C* to the lower part of *D*. This increased voltage across the fault gap again may result in restrike by the same mechanism as before in which case the voltage triangle would tend to be thrown in the positive direction in the form of a high-frequency oscillation between potential limits of minus and plus four, which in


A
Xs
A PHASE
GENERATOR OR TRANSFORMER
B
Xs
C
Xco
3-PHASE ESSENTIAL ELEMENTS
Xs
A PHASE
Ea - ELL/√3
Xco/3
EQUIVALENT CIRCUIT REFERRED TO A PHASE CONDUCTOR

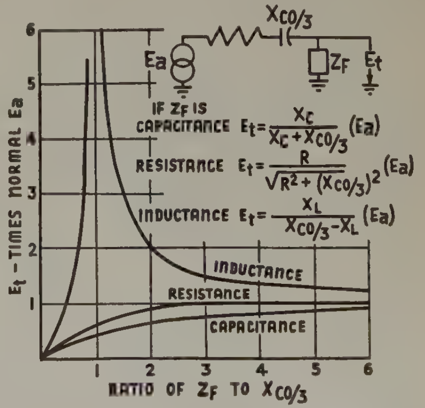


Figure 1 (left). Ungrounded 3-phase system. Figure 2 (right). Ungrounded systems: overvoltages due to ground fault through inductance

the presence of a solid metallic connection gradually would decay to zero.

In this explanation of the mechanism, it will be noted that all conditions have been most favorable to the creation of the highest possible restrike voltages in the shortest possible time. The restrike has been assumed to occur at the time the maximum recovery voltage was reached but not before. Likewise, it has been assumed that a reclear occurs at the first current zero after restrike. Under these conditions, a line-to-ground potential of five times normal has been developed in less than 2 cycles. In practical cases, the restrike may occur before the maximum recovery voltage has been reached and several cycles of the transitory oscillation may take place before the fault circuit reclears. While in theory it might be possible to increase progressively the line-to-ground voltage by successive restrike without limit if the dielectric strength progressively increases, voltage measurements on actual systems indicate that voltage levels of five to six times normal are rarely exceeded.

There is reason to believe that damaging overvoltages of repetitive restrike origin are far more common on ungrounded neutral systems than would be suspected at first. The case which was mentioned in an earlier paragraph is very unusual in that the obnoxious restriking conditions persisted for a long interval of time while the source was being located. A far more common occurrence is one in which several pieces of electric equipment on the system suffer electrical breakdown apparently simultaneously and one or more of the fault conditions was known or believed to involve ground. These multiple failures are rather commonly associated with ungrounded neutral system operation. It also is known that a solid metallic ground connection on one phase may exist for substantial intervals of time without producing multiple breakdowns in equipment although it does produce 73-per-cent overvoltage on two of the phase conductors. It, therefore, seems reasonable to assume that the multiple failures result from the appearance of overvoltages considerably in excess of 173-per-cent normal.

Distribution system overvoltages of repetitive restrike or intermittent ground origin can be eliminated entirely by effective system neutral grounding. Resistance grounding with a resistance ground fault of any value upwards of the line-to-ground charging current will be effective. For various other reasons, it will be evident that higher values of available ground fault current will be desirable. If reactance grounding is contemplated (it rarely finds application in industrial systems), it is important to keep the reactance of the grounding circuit sufficiently low so that the ratio X_0 is no more than ten times X_1. If this grounding reactance value is exceeded, opportunity is given for another type of repetitive restrike action which again can result in system overvoltage to ground.

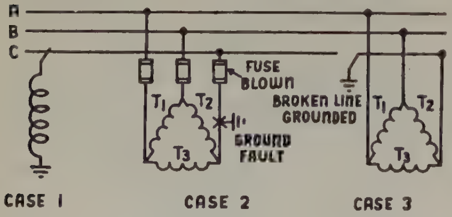


Figure 3. Examples of unintentional high-reactance connections between line and ground: Case 1. An inductive winding accidentally connected between one phase and ground. Case 2. A ground fault at a fuse-protected transformer can blow one fuse leaving the reactance of transformers T_2, and T_3, in parallel between line and ground.* Case 3. One broken overhead line grounded on the load side of the break connects the reactance of transformers T_2, and T_3, in parallel between line and ground*

* *Y ungrounded transformer connections would produce the same effect.*

SYSTEM GROUNDING—WHAT IS IT?

THE WORD "GROUND" as applied to electric power systems has a broad coverage. To be specific and to avoid misunderstanding, the subject is divided into two parts. "System Grounding" is defined in the National Electric Code as a connection to ground from one of the current-carrying conductors of a distribution system or of an interior wiring system. An "Equipment Ground" is a connection to ground from one or more of the non-current-carrying metal parts of the wiring system or of the apparatus connected to the system. These include all metal parts such as conduits, raceways, motor frames, or switch housings.

The discussion in this article is limited to neutral grounding of 3-phase a-c systems in industrial plants and comes under the foregoing classification of system grounding.

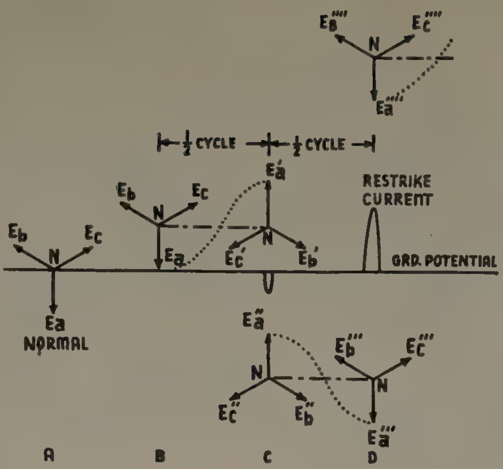
ADVANTAGES OF SYSTEM NEUTRAL GROUNDING

THE ADVANTAGES of operating an industrial power system grounded compared with operating it ungrounded may be one or more of the following:

1. Reduced operating and maintenance expense.
2. Improved service reliability.
3. Greater safety.
4. Better system and equipment overcurrent protection.
5. Improved lightning protection.

When the neutral of a system is not grounded, it is possible for destructive transient overvoltages of several times normal to appear from line-to-ground during normal switching of a circuit having a line-to-ground fault. Overvoltages may be developed by repeated restriking of the arc during interruption of a line-to-ground fault particularly in low-voltage systems. Experience has proved that these overvoltages may cause failure of insulation at other locations on the system than the point of fault. Thus, a line-to-ground fault on one circuit may result in damage to equipment and interruption of service on other circuits. The same condition will result from the repeated restrike of the arc in an arcing fault from line-to-ground. The condition described is illustrated in Figure 5.

In an ungrounded neutral system, a second ground fault on another phase may occur before the first fault is removed. The second fault may be on the same circuit as the original fault or on another. In any event, the resulting line-to-line fault will actuate relays or circuit breakers and trip either one or both circuits. Thus, a single ground fault of relative unimportance may result eventually in considerable damage due to the relatively high line-to-line fault current and the interruption of one or both circuits, see Figure 6.



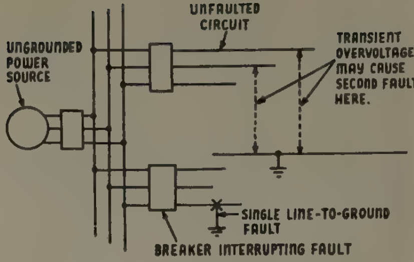


Figure 4 (left). Overvoltages developed by repetitive restrike on ungrounded systems. Figure 5 (above). Transient overvoltages during interruption of line-to-ground fault on ungrounded system

When the system neutral is properly grounded, these transient overvoltages are greatly reduced and experience shows that multiple ground faults are rare. Thus, from this consideration grounded neutral systems have lower operating cost and better service reliability.

When the neutral of a system is not grounded, a ground fault on one phase causes full line-to-line voltage to appear throughout the system between ground and the two unfaulted phases. This voltage is 73 per cent higher than normal.

Usually the insulation between each line and ground is adequate to withstand full line-to-line voltage. However, if this voltage is applied for long periods, it may result in failure of insulation which may have deteriorated due to age or severe service condition.

While multiple failures from this cause are less frequent than from transient overvoltages, nevertheless when one does occur, it means more maintenance and operating expense and lower service reliability. Properly grounded systems overcome these disadvantages.

Line-to-ground faults on ungrounded neutral systems cause a very small ground fault current to flow through the capacitance of cables, transformers, and other electric equipment on the system. This current may have a magnitude from a few amperes to 25 amperes or more on larger systems. This is not, in general, enough to actuate protective devices, but it may do considerable damage if allowed to flow for a long period of time.

In a system with neutral properly grounded, and with adequate overcurrent relaying, the ground fault current will be higher but it will be removed quickly. This often results in less damage at the point of fault and reduces the cost of repair.

Even though a plant operator may have experienced no displaced neutral, no excessive burning due to charging current, nor multiple faults due to transient overvoltages, it still costs money to find ground faults in an ungrounded neutral system. Ground detectors on an ungrounded neutral system will indicate the existence of a ground fault but will not give its location.

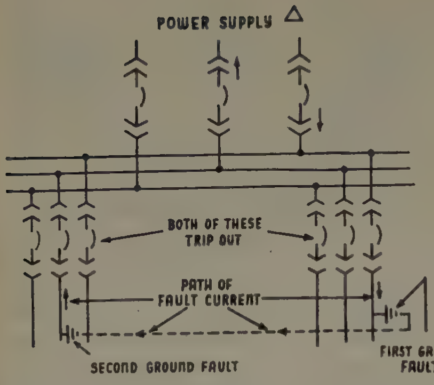
Several devices are available for determining the approximate location of ground faults but they, in general, require skill to operate and may not be too practical in the average industrial plant. The usual procedure in locating a ground fault is to open each circuit individually until the faulted current is located. Should there be two faults on the same phase of different feeders, all feeders must be opened and then closed one at a time to find the faulted feeder. This is costly and reduces service reliability because service is dropped while looking for the fault. Take the case of Figure 7 with a ground fault at *A*. While one can see from the diagram where the fault is, one usually cannot see where the ground fault is in an actual ungrounded plant power system. The first step is to open the secondary feeders one at a time. This will tell which feeder the fault is on. This means dropping at least one feeder if you are lucky and hit the grounded feeder first or all feeders if the ground is on the last feeder opened. After finding which feeder the fault is on, then the branch circuits are opened one at a time and finally the motors and loads taken off one at a time. If this is done during production hours, one readily can see how much production loss there will be just to find a ground fault in an ungrounded system. This is contrasted with a grounded neutral system where only the motor *A*, Figure 7, would have been tripped out and hence no other production machines interfered with.

Often it is argued, however, that with an ungrounded system one ground fault can be left on the system until it is convenient to locate it without interfering with production. Under modern working conditions this may mean after the regular shift, if the plant has only one shift. In some continuous processes like a paper mill, this means the fault locating can be done only on week ends. In processes that run the year round, such as a glass plant, it means that ground faults can be hunted only during vacations. In single-shift plants, hunting ground faults after regular working hours may mean overtime pay.

Because of the factors just mentioned, the tendency is to let the ground faults in an ungrounded system go until the plant shuts down or it is convenient to locate the fault. This practice, however, results in most cases in even poorer service continuity. While it is true that the grounded motor, Figure 7, was not affected with the first ground fault, the system having this one ground is subject to a double outage should a second ground fault occur on another phase.

When this happens, two circuits are tripped out. Now there are two emergency outages, and double the loss of production that would have occurred in grounded neutral system where the ground faults are isolated automatically. With service crews generally available, it takes more than twice as long to repair two ground faults at once than it does to repair two nonconcurrent faults particularly if the two concurrent faults are in isolated parts of the plants.

Experience has shown that double ground faults are



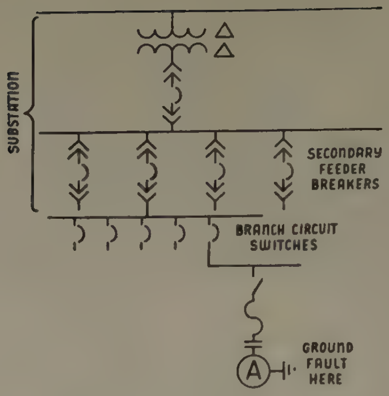


Figure 6 (left). Multiple ground faults. Figure 7 (right). Procedure in locating fault on an ungrounded neutral system

common in ungrounded systems simply because the first ground is left on hoping that the operator will find it before the second ground fault occurs. In other words, most ungrounded systems are grounded accidentally most of the time anyway.

Since grounded motors and circuits have to be removed for repair, why not use a grounded neutral system which will indicate which motor or circuit is grounded so that the faulty part can be removed and repaired as soon as the ground fault occurs, instead of using an ungrounded system and running the risk of having to repair two faulty pieces of equipment at once and take double the production outage.

The grounding of 208Y/120-volt systems has been adopted almost universally. Grounding the neutrals of 480- and 600-volt systems has been impractical in the past because all 3-phase transformers supplying these voltages have been historically delta-connected.

Now standard load center unit substations are available with Y-connected secondary windings rated 208Y/120, 480Y/277, or 600Y/346 volts, and which enables low-voltage system neutral grounding which provides a safer, more reliable, and lower operating cost power distribution system. These substations are available with delta-connected primary windings.

The new standard Y-connected secondary windings for the 480- and 600-volt substations enable these units to be used for either grounded neutral or ungrounded 480- or 600-volt systems respectively. The low-voltage neutral is brought out through a bushing. When grounding is desired, the terminal of the neutral bushing is connected to the low-voltage ground bus. When grounding is not desired, this connection is left off. Therefore, one line of unit substation transformers now provides all the voltage ratings commonly required plus the advantage of being able to operate the low voltage either grounded or ungrounded. Substations rated 240 volts are delta-connected. To obtain grounded neutral operation in this voltage class, either the 208Y/120-volt substations or 240-volt delta substations with grounding transformers may be used.

Low-voltage grounded-neutral systems are more reliable and less costly to maintain and operate than ungrounded low-voltage systems. This is due to reasons already outlined, that is, elimination of overvoltages which deteriorate insulation and which cause multiple breakdowns and in grounded neutral systems properly relayed, the ground faults are isolated automatically to save taking the time and spending the money to take the system out of service or to use a ground fault locator to find the ground faults.

Low-voltage grounded-neutral systems are safer than ungrounded systems. The neutral is held at ground potential (where a proper electrical path to ground is maintained) and, therefore, the potential of any conductor to ground is limited to about 277 volts maximum at 480 volts line-to-line or about 346 volts maximum at 600 volts line-to-line. In an ungrounded system the actual neutral floats somewhere near the true electric neutral due to the capacitance effect of the system conductors. Therefore when there is no ground on an ungrounded system, the shock hazard is no greater than on a grounded neutral circuit. Since there is a current flow of only a few amperes charging current when one conductor of an ungrounded system becomes grounded, air circuit breakers or fuses will not operate to remove the faulty circuit. Hence, the ground fault on an ungrounded system may remain there until the operator tracks it down and removes it. Because of the difficulty of finding these ground faults, they may be left on ungrounded low-voltage systems for extended periods of time. During this time, there is full line-to-line voltage between two conductors and ground of an ungrounded system, hence, an increased shock hazard should anyone accidentally touch one of the ungrounded conductors.

It should be emphasized that in referring to a grounded neutral system, the neutral is grounded at the substation and is not carried to the distribution system. As far as the distribution system is concerned, only the 3-phase wires are carried through. It makes no difference as to what type of 3-phase electric equipment is used on the system. That is, motors, transformers, and other pieces of equipment can be connected in any manner internally and there is no reason for grounding the neutral of the motor winding or other utilization equipment.

The first cost of a grounded neutral 3-wire 480- or 600-volt unit substation is about the same as a unit substation with delta secondary connections and ground detectors.

Further savings of about $15 to $30 per kilovolt-ampere of lighting load can be made by using 264-volt fluorescent lamp ballasts fed directly from a 480Y/277-volt unit substation for general area factory lighting.

RECOMMENDED METHODS OF GROUNDING THE NEUTRAL

Old Systems. The grounding of existing systems previously operated ungrounded will present many perplexing problems. Service transformers usually will be found to be delta-connected. Ideal neutral grounding can be accomplished using a separate grounding transformer. Mid-phase grounding is a next best solution but limited to cases using banked single-phase transformers. Corner-of-the-delta grounding also will achieve most of the desired objectives but with a somewhat greater number of undesirable compromises.

Unless the existing system is in good condition, of reasonably modern design, and adequate from a short-circuit standpoint, the best long-range plan for the customer well may be a modernization program using new load-center unit substations.

Grounding Transformer. Application of a grounding transformer is one possible solution. It is desirable that sufficient ground fault current be available to actuate instantaneous trip coils on feeder circuit breakers. This would be 15 times the rating of the largest feeder circuit breaker, thus the size and cost of a suitable grounding transformer will be a sizeable item.

Corner-of-Delta Grounding. The grounding of one phase conductor often is proposed as a solution to the system grounding problem. While this procedure will satisfy most of the system grounding objectives, it contains several rather serious disadvantages, namely:

1. Throughout the system, two phases are forced to operate continuously with a line-to-ground potential 73 per cent greater than necessary; while the third operates with zero electrical stress.
2. The National Electrical Code requires that motor circuits containing only two overload relays be so wired that the overload units are in the ungrounded conductors. Meeting this requirement could be an annoying costly proposition.
3. A ground fault on the grounded phase conductor causes no protector operation yet allows diversion of load current to the building ground system at the point of fault contact with attendant sputtering and local heating.
4. Sustained operation of circuits with 100-per-cent zero sequence voltage (one conductor at ground potential) may be responsible for induction of stray signals into adjacent signal or communication circuits.

In view of these compromises involved in corner-of-delta grounding, it would be well to recommend strongly that the user adopt neutral grounding conceding corner-of-delta grounding as a compromise solution, which well might prove to be more expensive than neutral grounding on an over-all basis.

Mid-Phase Grounding. Grounding of the mid-point of one phase of the delta is applicable to banked single-phase transformers. While this method of grounding is less desirable than neutral grounding, it is better than corner-of-the-delta grounding. All phase conductors are "hot" to ground. One conductor would operate at 150 per cent while the other two would operate at 87 per cent of the ideal potential to ground.

Keep in mind that this grounding method is applicable to banks of single-phase transformers. It offers no advantage in the case of 3-phase transformers. It never would it be considered for a load center substation.

CONCLUSIONS

PROPER SYSTEM GROUNDING pays dividends on low- as well as medium-voltage systems. The number of industrial plants operated with grounded electric systems has been expanding rapidly. Many critical industrial process plants such as glass, paper, steel, and cement are operating with their low-voltage system grounded. From these critical process plants as well as others, the operating data show improved electric system performance and fewer equipment outages after the grounding of the distribution system.

The problem now is one of education to overcome the inertia of years of ungrounded system experience. Without a doubt, the ungrounded system originated as a happenstance rather than a planned affair. The three terminals of the source were simply connected through to the three terminals of the load machines. The 480-volt Y transformer is now a listed standard load center substation with many manufacturers. This is suitable for universal service, grounded or ungrounded. Plant engineers who now believe that ungrounded operation is better should be strongly urged to adopt the 480-volt Y substation. It will meet their present desired ungrounded service requirements and 2 or 3 years hence, when they become convinced of the merits of the grounded operation, the stations can be converted by merely grounding the low-voltage neutral bushing to ground. The number of unit substations sold by the electrical industry in the last 4 years has shown an astounding rise in the proportion of transformers with a neutral bushing brought out so that the system can be operated as a grounded neutral system if so desired.

This marks a very definite trend by the electrical industry; the grounded neutral system for industrial plant operation will become more and more universal as time passes and every electrical engineer concerned with industrial plant electrical operation should be well aware of the merits.

Reactor Sphere Completed

The Atomic Energy Commission has announced that the large steel sphere at the Knolls Atomic Power Laboratory, West Milton, N. Y., has been completed. The sphere will be used for test operations by the General Electric Company on a prototype atomic power plant for submarines.

Closing of the last openings at top and bottom marked the end of 10 months' work. A total of 682 steel plates were joined together to make the structure which, together with its supporting columns, weighs 3,850 tons. The sphere is 225 feet in diameter and is higher than an 18-story building.

Purpose of the housing is to provide insurance against the escape of radioactive material in the remote chance that numerous safety devices fail simultaneously. The atomic reactor will be installed in a land-based submarine hull section. Water will surround part of this hull inside the sphere to simulate actual sea-going conditions.

Differential Reactive Current Protection Relay

R. W. STINEMAN

A PROTECTIVE DEVICE which the author has called a differential reactive current protection relay (DRCPR) was developed for use in an aircraft a-c electric system, as a solution to a number of problems associated with reactive load division. This protective device is equally applicable to any system of paralleled alternators with automatic voltage regulation.

A schematic diagram of a simplified version of the DRCPR which may be used to illustrate the principles of operation is shown in Figure 1. The polarized relay has two opposing coils, the one on the left of the figure being connected through a bridge rectifier directly to the line transformer and hence serving as a reference. The other relay coil is energized by the secondaries of the line transformer and mutual reactor connected in series. If the alternator delivers other than its share of current to the bus, then a current flows in the primary of the mutual reactor which is proportional to the deviation of the alternator current from the desired current. This characteristic of a current transformer loop is described more fully by Granath and Hawkes.[1] As a result of the current in the mutual reactor primary, a voltage is induced in the mutual reactor secondary which affects the voltage applied to the right-hand coil of the polarized relay. The vector relations are illustrated in Figure 2 for the case where the alternator is delivering more than its share of lagging reactive current, such as would occur if a voltage regulator malfunction caused overexcitation of the alternator. Since the mutual reactor secondary voltage leads the primary current by an angle approaching 90 degrees, the voltage applied to the right-hand relay coil in this case is increased, actuating the relay armature to the right. If the alternator were to deliver less than its share of lagging reactive current, then the mutual reactor vectors would be reversed and the relay armature would be actuated to the left. For real current unbalances, the mutual reactor vectors would be rotated 90 degrees and the unbalance would have little or no effect on the polarized relay.

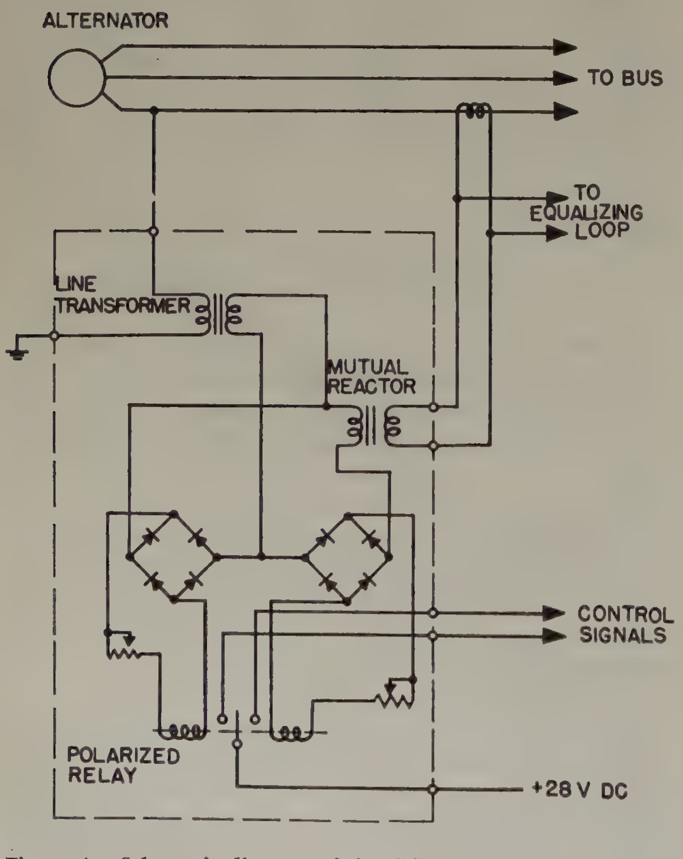


Figure 1. Schematic diagram of the differential reactive current protection relay

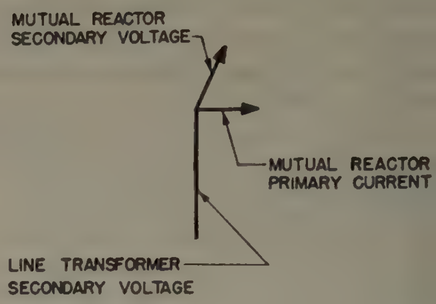

MUTUAL REACTOR SECONDARY VOLTAGE
MUTUAL REACTOR PRIMARY CURRENT
LINE TRANSFORMER SECONDARY VOLTAGE

Figure 2. Vector diagram for the transformer and mutual reactor

In the application for which the DRCPR was developed, one control signal was used to trip a circuit breaker to isolate the alternator if overexcited, the other to energize a warning light should the alternator lose its excitation. In the case of overexcitation, conventional overvoltage protection was cut in after the circuit breaker had tripped. The particular application would govern the manner in which the control signals would be applied. Care must be taken to avoid false trips or indications, since whenever a faulty alternator is delivering more than its share of current, then the other alternators must be delivering less than their shares.

The DRCPR has considerable inherent flexibility and may be adapted to many situations. Simple changes in the external connections to the unit will cause it to respond to real rather than reactive current. Other simple modifications in the external connections will cause the unit to respond to various combinations of real and reactive current.

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Impedance Transformations in Band-Pass Filters

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DESIGN OF band-pass impedance transforming filters is derived from Norton's[1] equivalence between a dissymmetrical band-pass filter and a symmetrical section plus an ideal transformer. This equivalence is illustrated for a T section in Figure 1. The dissymmetrical section is exactly equivalent to the symmetrical section if

$$Z_A = Z_1 - Z_2(r-1)$$

$$Z_B = r^2 Z_1 + r(r-1)Z_2$$

$$Z_C = rZ_2.$$

Similar equivalences exist for "Pi" sections. The design of a network for a specific transformation may proceed by (1) selection of the symmetrical section ideal transformer system; (2) determination of the dissymmetrical section constants from the equivalence formulas. Limits of physical realizability can be imposed in several ways, two of which lead to classes of general interest.

Case a. No negative circuit elements appear in any network branch. Network sections synthesized with this restriction result in cascades in which the maximum impedance ratio varies from section to section, decreasing as the impedance level increases. The over-all ratio of such a cascade is given by

$$r = T_n(1 + N_1/N_2)$$

in which T_n is the Tschebyscheff polynomial[2] of order n. The quantity $1 + N_1/N_2$ can be expressed in terms of the cutoff frequencies of the passband by a relation dependent on the form of symmetrical section from which the synthesis proceeds.

Case b. No negative circuit elements appear in any interior branch of a cascade. Networks synthesized with this restriction make use of the cancellation of a negative circuit element in one section by a positive element in an adjacent section to form a resultant structure with positive elements only. A cascade of such sections has a negative element in either input or output branch which is not matched by a positive element. This leftover negative circuit element may be eliminated by a special input or output section with the appropriate positive element. The transformation ratio of a cascade of n sections of this type, excluding input or output section, is given by

$$r = \left[(N_1/N_2 + 1) + \sqrt{N_1^2/N_2^2 + 2N_1/N_2}\right]^n$$

This ratio is always higher than that for a synthesis based upon the restrictions of case *a*. On the other hand a minimum of two sections, basic section plus matching section, is required so that a single section based upon case *a* is likely to be more economical for small impedance ratios or narrow bands. An example of a useful single section (case *a*) impedance transformer is given in Figure 2.

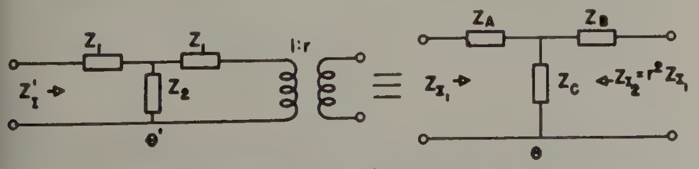

Figure 1. Norton's equivalence for a T section

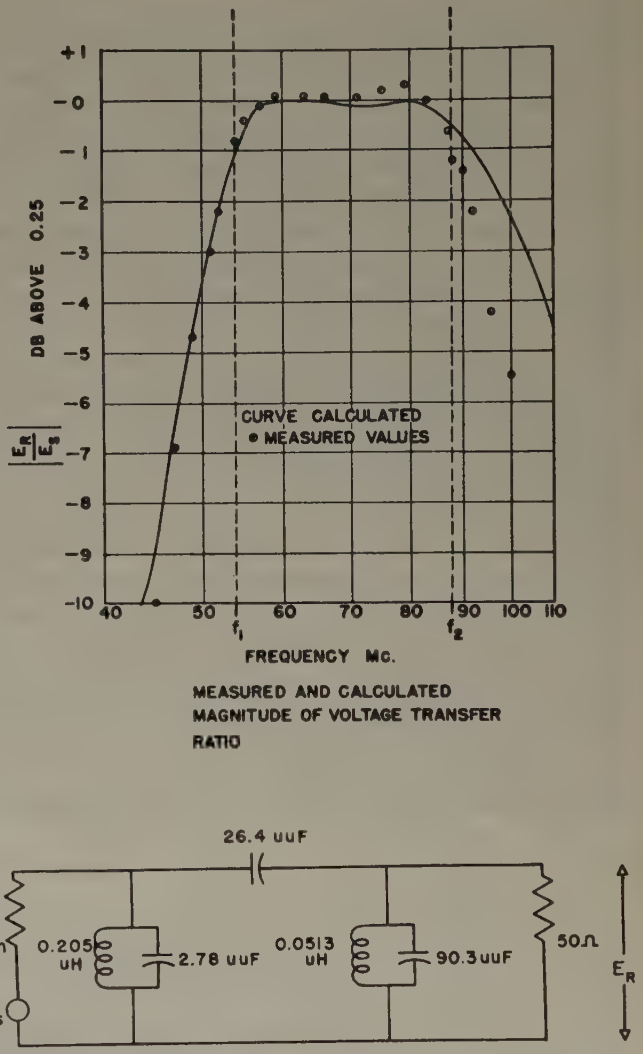

Figure 2. (Top) Calculated and measured values of voltage transfer ratio in the circuit shown. (Bottom) Constants of a single section type (a) filter design for 200- to 500-ohm transformations for the frequency range of television channels 2 through 6

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Digest of paper **53-143**, "Maximum Impedance Transformations in Band-Pass Filters," recommended by the AIEE Committee on Special Communications Applications and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Analysis of a Limiter as a Variable-Gain Device

L. R. KAHN

This method for analyzing the effect of a limiter upon a signal is based upon a simple physical concept of the limiter and does not require the use of advanced mathematical techniques. The limiter is treated as a variable-gain device which amplitude modulates the input signal. Two examples demonstrate the new method.

THE METHOD of determining the output spectrum of an amplitude limiter presented here also may be used to solve the related problem of ascertaining the side-band spectrum of the angle-modulation component of a signal. A limiter has been defined as "a transducer whose output is constant for all inputs above a critical value. Note: A limiter may be used to remove amplitude modulation and transmit angle modulation."[1] The following analysis treats a limiter as a device which varies its gain so that the amplitude-modulation component of the input wave is eliminated. Thus, when the amplitude-modulation component changes the level of the signal wave, the gain of the limiter is altered in such a manner as to maintain constant output level. In this manner, the amplitude-modulation component is erased.

The input wave as shown in Figure 1*A*, will be used to describe the variable-gain characteristic of a limiter. This input wave has both amplitude- and angle-modulation components. As has been mentioned, the purpose of the limiter is to remove the amplitude-modulation component signal, thereby leaving a pure phase-modulated wave. The conventional limiter removes the amplitude-modulation component by converting the input wave into a constant-amplitude angle-modulated square wave. If the limiter is considered as a variable-gain device, it readily can be seen how the square wave is derived from the input wave. Figure 1*B* shows the instantaneous limiter gain function* of the limiter. When this instantaneous-limiter gain function amplitude modulates the input wave a square wave is produced as shown in Figure 1*C*. When the limiter is tuned, the square wave is converted into a sinusoidal wave as shown in Figure 1*D*.

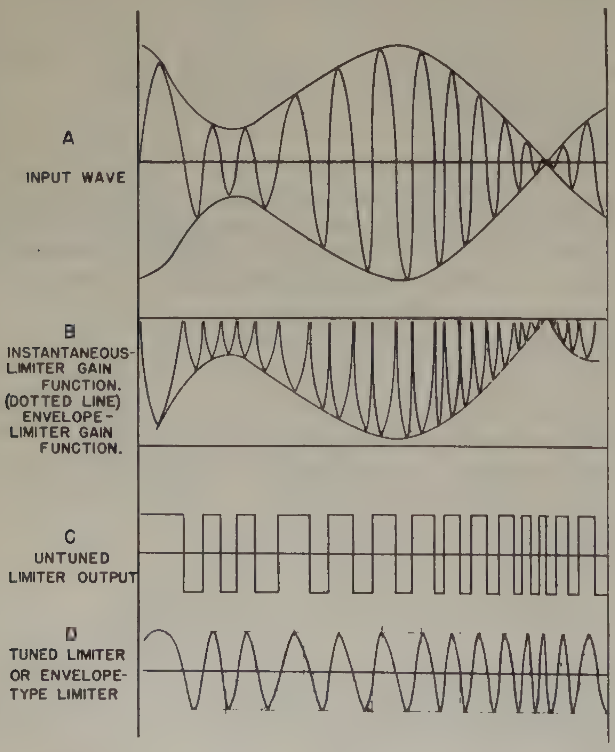
A
INPUT WAVE
B
INSTANTANEOUS-LIMITER GAIN FUNCTION. (DOTTED LINE) ENVELOPE-LIMITER GAIN FUNCTION.
C
UNTUNED LIMITER OUTPUT
D
TUNED LIMITER OR ENVELOPE-TYPE LIMITER

Figure 1. Waveforms demonstrating method of analysis

The dotted curve in Figure 1*B* is called the envelope-limiter gain function. When this function modulates the wave shown in Figure 1*A*, the angle-modulated sine wave in Figure 1*D* is produced. The envelope-limiter gain function *ELGF*(*t*), is equal to the inverse of the envelope of the input wave.

$$ELGF(t)=1/F(t) \tag{1}$$

where $F(t)$ is the equation of the envelope of the input signal.

Modulation by this envelope-limiter gain function erases the envelope variations which in effect is the same as eliminating the amplitude-modulation component of the wave. It does this erasing without distorting the waveshape of the carrier. Therefore, only the fundamental spectrum of the angle-modulated wave is produced. Since most limiter applications do not utilize the harmonic content of the limiter, and in fact are tuned to eliminate the harmonic spectra, analysis using the envelope-limiter gain function gives a more practical answer to most problems than using the more complicated instantaneous-limiter gain function.

The envelope-limiter gain function is a relatively simple function which readily is analyzed in terms of its Fourier series components. Use of the envelope-limiter gain func-

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The author wishes to acknowledge the helpful comments of the Long-Range Section o Coles Signal Laboratory, who administered Contract Number DA36-039 sc-15359 under which this work was done by the author while associated with Crosby Laboratories Inc. M. G. Crosby also is to be thanked for his many comments on the author' work. Others whose comments on this article are acknowledged gratefully are J. L. Finch and Walter Lyons of Radio Corporation of American Communications Inc., V. D. Landon and B. A. Trevor of RCA Laboratories, and R. T. Nelson of Crosb Laboratories, Inc.

*It should be noted that two similar terms, *instantaneous* limiter gain function and *envelop* limiter gain function are used herein. It will be shown that modulation of the inpu wave by the *instantaneous* limiter gain function produces an angular modulated *squar wave* whereas modulation by the *envelope* limiter gain function produces an angular modulated wave without distorting the waveshape of the carrier.

tion allows a simple approach to the basic problem of determining the angle-modulated side-band spectra of a wave, or what is the same thing, the fundamental spectrum output from a limiter. As will be shown, this method does not involve the use of Bessel functions and the calculations are relatively simple.

The limiter therefore may be considered as an amplitude modulator which modulates the input signal by the envelope-limiter gain function. When the input spectrum components are multiplied (amplitude modulated) by the envelope-limiter gain function, a new side-band distribution is produced wherein the input frequency components are carriers modulated by the envelope-limiter gain function. This side-band distribution is the fundamental output of the ideal limiter.

THE ANALYSIS

THE METHOD may be outlined in the following series of steps:

1. The signal wave fed to the limiter is fully described as to the amplitude, frequency, and relative phase of the spectrum components.
2. The envelope function, $F(t)$, of the input wave is determined.
3. The inverse function of the input envelope function, $1/F(t)$, is next calculated. This is the envelope-limiter gain function, $ELGF(t)$.
4. The Fourier series describing the envelope-limiter gain function determined in step 3 is calculated.†
5. Each individual input signal component described in step 1 is amplitude modulated (multiplied) by the Fourier series of the envelope-limiter gain function. The resulting spectrum is the desired output of an ideal limiter and therefore it is the phase-modulation component of the input wave described in step 1.

HARMONIC CONTENT OF A LIMITER

THE PRECEDING ANALYSIS may be extended to determine the harmonic content of limiters. This problem is, however, of less importance in practical work than the determination of the fundamental spectrum. In order to determine the harmonic content, it is necessary to use an instantaneous-limiter gain function shown in Figure 1*B*. This wave is considerably more complex than the envelope-limiter gain function.

Dr. D. G. Tucker in a recent article[2] described a technique of analyzing limiters. His method requires the determination of a square wave that is phase modulated by the phase-modulation component of the input wave. This square wave is then multiplied by the input-wave equation. It would appear that this method would produce results similar to results obtained by use of the instantaneous-limiter gain function.

TWO-TONE SIGNAL PROBLEM

AS AN INTRODUCTORY EXAMPLE of the application of this analysis, the side-band distribution of the phase-modulation component of a wave composed of two tones, one being ten times the other in magnitude, will be determined. A spectrum diagram of the problem is shown in Figure 2*A*. The Fourier series describing the envelope of this wave has been calculated by Moullin.[3,4] The series for this particular ratio of signal amplitude is to a close approximation.

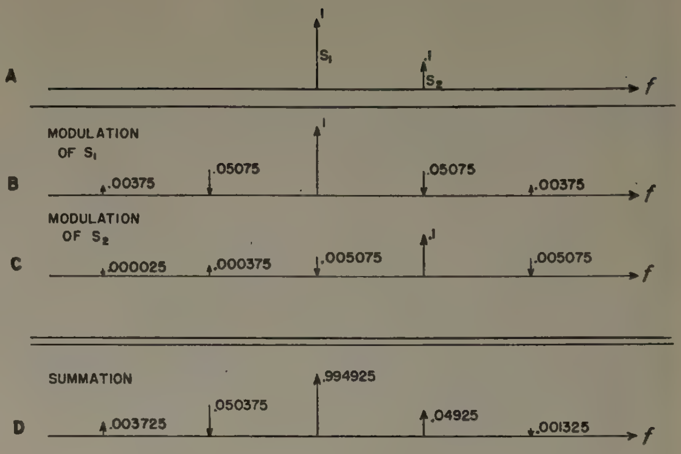

Figure 2. Two-tone problem (numbers given are not rounded off in order to clarify calculations)

$$F(t) \approx 1+0.1 \cos wt - 0.0025 \cos 2wt \qquad (2)$$

where $w = 2\pi f$ and f is the frequency separation between S_1 and S_2.

Step 3 in the analysis calls for determination of the envelope-limiter gain function and, therefore, the next step is to solve for the inverse of the envelope equation.

$$ELGF(t) = \frac{1}{\text{Envelope}} \approx \frac{1}{1+0.1 \cos wt - 0.0025 \cos 2wt} \qquad (3)$$

using the relationship $\cos 2\theta = 2\theta \cos {}^2\theta - 1$, the inverse of a power series into terms of $\cos wt$ can be obtained.

$$ELGF(t) \approx \frac{1}{1+0.1 \cos wt - 0.005 \cos {}^2wt} \qquad (4)$$

dividing and using trigonometric identities, the following relationship is obtained:

$$ELGF(t) \approx 1 - 0.1015 \cos wt + 0.0075 \cos 2wt - 0.0005 \cos 3wt \qquad (5)$$

Knowing the equation for the limiter gain function and the side-band distribution for each of the two input components, step 5 is performed readily. The spectrum resulting from the modulation of S_1 by the limiter gain function is shown in Figure 2*B*. Figure 2*C* shows the result of modulation of S_2 by the limiter gain function. These frequency components are vectorially summated and the result, Figure 2*D*, is the output of the limiter. These side bands are the

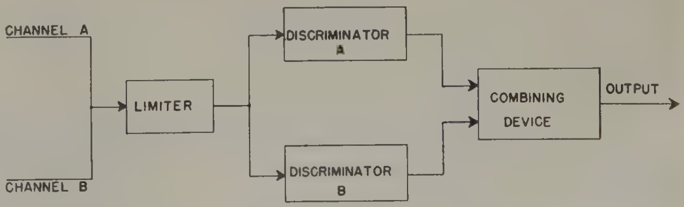

Figure 3. Common limiter diversity unit

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†In many cases, it will be less laborious to do step 4 before step 3. In the following "2-tone example" step 4 was calculated before step 3.

Table I. Common Limiter Diversity Signal-to-Noise Ratios

Input S_1/N_1 Decibels	S_1	N	ϵrad	$\left[\log \frac{\sin\theta}{1+\cos\theta}\right]_{\epsilon}^{\pi-\epsilon}$	πA_0	$\frac{\pi B_2}{2}$	πS_1 Out	πN_1 Out	S_1/N_1 Out	S_1/N_1 Out Decibels	Loss Decibel
17	5	1	0.1	6.0	0.8	0.4	2.0	0.635	3.15	10.0	7.0
23	10	1	0.051	7.4	0.47	0.27	2.0	0.382	5.24	14.4	8.6
29	20	1	0.025	8.8	0 27	0.17	2.0	0.224	8.94	19.0	10.0
33	31.6	1	0.016	9.64	0.184	0.12	2.0	0.158	12.6	22.0	11.0
83	10^4	1	0.5×10^{-4}	21.2	11.6×10^{-4}	9.6×10^{-4}	2.0	10.7×10^{-4}	1.87×10^3	65.4	17.6

side bands of the phase-modulation component of the input wave. It should be noted that this side-band distribution problem was solved without the use of Bessel functions which is characteristic of the method.

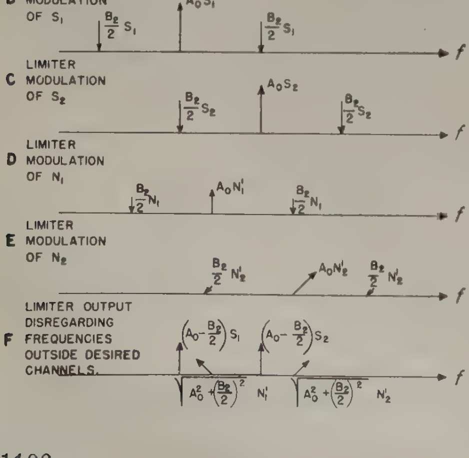
COMMON LIMITER DIVERSITY PROBLEM

An important practical illustration of the previously described method concerns the common-limiter diversity system. This diversity system has been described a number of times[5,6] and therefore a thorough description of it is not necessary. The common-limiter system, as shown in Figure 3, utilizes the capture effect of limiters to reduce the amplitude of the weaker signal. In this manner, the stronger signal is always favored. The two signals to be combined are fed to the grid of a limiter. One signal differs in frequency from the others by an appreciable amount. The output of the limiter is fed to separate discriminators tuned to the diversity frequencies.

This analysis determines the amount of degradation in signal-to-noise of the common-limiter diversity system under certain assumed conditions. It will be shown that the signal-to-noise ratio of the combined output wave is worse than that of the better diversity input signal. This effect is most noticeable when the input diversity signals are equal or nearly equal in level.

It should be noted that the following analysis only considers one of the many characteristics of this form of diversity and should not be considered as a complete appraisal of this system. Of course, it is an important effect and should be considered in any complete study of the system.

A qualitative examination of this system reveals that there should be some signal-to-noise degradation in the system. This may be seen by using the afore described method of treating a limiter as a variable-gain device which varies its gain as an inverse function of the input signal level. Thus, when the input-wave level is minimum, the gain of the limiter is at a maximum. During periods when the input signals are of such relative phase as to tend to balance out, the resultant wave fed to the limiter is reduced and the gain of the limiter tends to increase so as to maintain a constant output. During these periods of signal bucking, the signal-to-noise ratio is reduced because the noise is relatively constant. When the signals are of such phase that the input wave is large and therefore its signal-to-noise is increased, the gain of the limiter is reduced. Thus, the gain of the system varies as an inverse function of the instantaneous signal-to-noise ratio thereby degrading the output signal-to-noise ratio.


A SIGNAL INPUT
S_1
N_1'
S_2
N_2'
f
B LIMITER MODULATION OF S_1
$\frac{B_2}{2} S_1$
$A_0 S_1$
$\frac{B_2}{2} S_1$
f
C LIMITER MODULATION OF S_2
$\frac{B_2}{2} S_2$
$A_0 S_2$
$\frac{B_2}{2} S_2$
f
D LIMITER MODULATION OF N_1
$\frac{B_2}{2} N_1$
$A_0 N_1'$
$\frac{B_2}{2} N_1$
f
E LIMITER MODULATION OF N_2
$\frac{B_2}{2} N_2'$
$A_0 N_2'$
$\frac{B_2}{2} N_2'$
f
F LIMITER OUTPUT DISREGARDING FREQUENCIES OUTSIDE DESIRED CHANNELS.
$\left(A_0 - \frac{B_2}{2}\right) S_1$
$\left(A_0 - \frac{B_2}{2}\right) S_2$
$\sqrt{A_0^2 + \left(\frac{B_2}{2}\right)^2}\ N_1'$
$\sqrt{A_0^2 + \left(\frac{B_2}{2}\right)^2}\ N_2'$
f

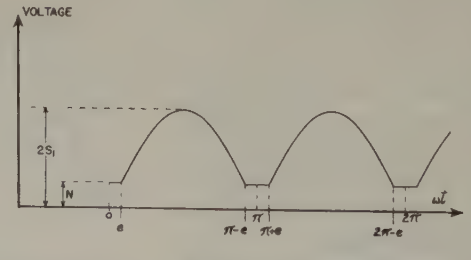


Figure 4 (left). Results of common limiter diversity calculations. Note: Only B_2 is considered, higher components are outside filters. Figure 5 (above). Approximate envelope-limiter gain function in common-limiter diversity

ASSUMPTIONS

The following assumptions are made:

1. A dual-receiver diversity system is used.
2. Signal 1 (S_1) equals Signal 2 (S_2).
3. Noise 1 (N_1) equals Noise 2 (N_2). Noise 1 is the noise that accompanies Signal 1 and Noise 2 is the noise that accompanies Signal 2.
4. The noise is random and therefore noise components add powerwise.
5. The amount of limiting is sufficient to maintain a constant output level. Increasing the amount of limiting over this point does not affect the output wave.
6. The ratio of S_1/N_1 and S_2/N_2 is equal to or greater than 5.

CALCULATIONS

Step 1. The frequency components of the input wave to the limiter are shown in Figure 4*A*. S_1 is the signal in Channel 1, S_2 the signal in Channel 2. The noise N_1' is one of an infinite number of noise components in Channel 1. N_2' is one of the infinite number of noise components in Channel 2 and it has random phase relative to noise N_1'. At the instant shown in the vector drawing, S_1 is in phase with S_2.

Step 2. The amplitude-modulation component of the input wave is shown approximately in Figure 5. The wave follows a cosine shape for most of the period, however, when the signal approaches cancellation, the noise component predominates. Since the noise is assumed to be random its level is fairly constant. Therefore, during periods of almost total signal cancellation the input wave is almost constant. This input wave is closely approximated mathematically as follows:

$$F(t) \approx \Big[N\Big]_0^e + \Big[2S_1 \sin\theta\Big]_e^{\pi-e} + \Big[N\Big]_{\pi-e}^{\pi+e} + \Big[-2S_1 \sin\theta\Big]_{\pi+e}^{2\pi-e} + \Big[N\Big]_{2\pi-e}^{2\pi} \quad (6)$$

where N equals the rms sum of N_1 and N_2.

Step 3. The envelope-limiter gain function, $ELGF(t)$, which is the inverse function of step 2, is determined. This function may be defined by the following equation.

$$ELGF(t) = 1/F(t) \approx \Big[1/N\Big]_0^e + \Big[\frac{1}{\sin\theta}\,\frac{1}{2S_1}\Big]_e^{\pi-e} + \Big[1/N\Big]_{\pi-e}^{\pi+e} + \Big[\frac{-1}{\sin\theta}\,\frac{1}{2S_1}\Big]_{\pi+e}^{2\pi-e} + \Big[1/N\Big]_{2\pi-e}^{2\pi} \quad (7)$$

where $e = \text{arc}\sin N/2S_1$.

Step 4. Next, the Fourier series describing this wave is determined. The fundamental frequency of the Fourier series is assumed to be equal to one-half the frequency separation between the signal frequencies in order to simplify calculations. Due to this choice of fundamental frequency, there are no odd harmonic terms. The d-c component and the second harmonic term only need be calculated because the higher harmonics fall outside the discriminator's passband. The d-c component equals:

$$\begin{aligned}
A_0 &= \frac{1}{\pi}\int_0^{\pi} ELGF(t)\,d\theta \\
&= \frac{1}{\pi}\left[\int_0^e \frac{1}{N}\,d\theta + \int_e^{\pi-e} \frac{1}{\sin\theta}\,\frac{1}{2S_1}\,d\theta + \int_{\pi-e}^{\pi} \frac{1}{N}\,d\theta\right] \\
&= \frac{1}{\pi}\left[\frac{2_e}{N} + \left(\frac{1}{2S_1}\log\left\{\frac{1-\cos\theta}{\sin\theta}\right\}\right)_e^{\pi-e}\right] \\
&= \frac{1}{\pi}\left[\frac{2_e}{N} + \left(\frac{1}{2S_1}\log\left\{\frac{\sin\theta}{1+\cos\theta}\right\}\right)_e^{\pi-e}\right] \qquad (8)
\end{aligned}$$

where $e = \text{arc}\sin N/2S_1$.

Due to the choice of fundamental frequency, the fundamental component is equal to zero. The second harmonic term is equal to:

$$\begin{aligned}
B_2 &= \frac{2}{\pi}\int_0^{\pi} ELGF(t)\cos 2\theta\,d\theta \\
&= \frac{2}{\pi}\left[\int_0^e \frac{\cos 2\theta\,d\theta}{N} + \int_e^{\pi-e} \frac{1}{2S_1}\,\frac{\cos 2\theta\,d\theta}{\sin\theta} + \int_{\pi-e}^{\pi} \frac{\cos 2\theta\,d\theta}{N}\right] \\
&= \frac{2}{\pi}\left[\frac{1}{2N}\Big(\sin 2\theta\Big)_0^e + \frac{1}{2S_1}\left(\log\frac{\sin\theta}{1+\cos\theta}\right)_e^{\pi-e} + \frac{2}{2S_1}\Big(\cos\theta\Big)_e^{\pi-e} + \frac{1}{2N}\Big(\sin 2\theta\Big)_{\pi-e}^{\pi}\right] \\
&= \frac{1}{\pi}\left[\frac{2}{N}\sin 2e - \frac{4\cos e}{S_1} + \left(\frac{1}{S_1}\log\frac{\sin\theta'}{1+\cos\theta}\right)_e^{\pi-e}\right] \qquad (9)
\end{aligned}$$

Step 5. The two signal components and the two noise components are modulated separately by the limiter gain function determined in step 3. The result of this process is shown in Figure 4*B*, *C*, *D*, and *E*.

The resulting spectra are summated vectorially and the result is shown in Figure 4*F*. This summation shows all the components that lie within the passband of the discriminator. The S_1 output of the limiter is equal to:

$$S_{1\text{out}} = \left(A_0 - \frac{B_2}{2}\right)S_1 \qquad (10)$$

The noise components have a random phase relation and therefore the resultant N_1 component is equal to:

$$N_{1\text{out}} = \left(A_0^2 + \frac{B_2^2}{4}\right)^{1/2} N_1 \qquad (11)$$

Table I shows the calculations made to determine the signal-to-noise degradation due to this factor. It should be stressed that this effect is maximum when the input signals are equal in amplitude. It is seen that this effect accounts for approximately 7 to 11 decibels signal-to-noise degradation when the input signal-to-noise ratio is from 14 to 30 decibels. These relations are shown graphically in Figure 6. Also shown in Figure 6 is an experimental curve substantially confirming the calculations.

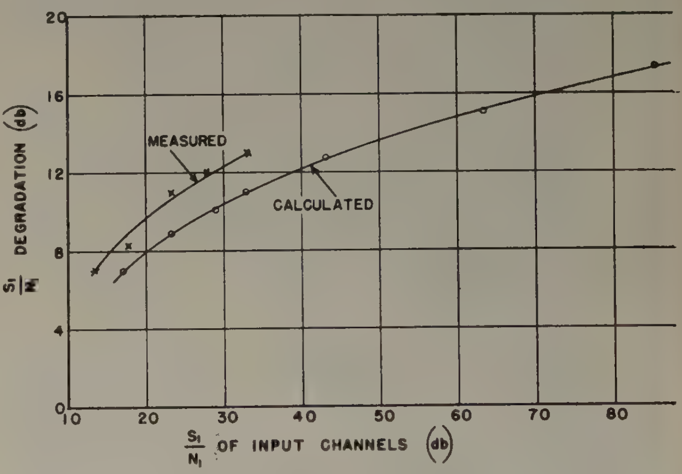


Figure 6. Common limiter signal-to-noise ratio degradation

The foregoing analysis indicates that the output wave has a poorer signal-to-noise ratio than either of the two input signals. This is just one of the many characteristics of this form of diversity system and there are many other considerations required before a thorough appraisal of this system can be made.

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5. Frequency-Shift Telegraphy Radio and Wire Applications, **J. R. Davey, A. L. Matte.** *Bell System Technical Journal* (New York, N. Y.), volume 27, April 1948, pages 265–304.

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240/416-Volt Power and Lighting Supply

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FELLOW AIEE

THE OBJECTIVE of this article is to point out the disadvantages of a 480-volt supply system for manufacturing plants and to emphasize the advantages of a 240/416-volt 3-phase 4-wire supply for both power and lighting.

Data indicate that the average load on the 3-phase motors in the modern manufacturing plant is considerably below the name-plate rating. These data, when referred to motor performance curves, indicate that the operation at either 208 or 416 volts would improve the power factor and the efficiency to such an extent that the current in the plant feeders would be less than at 240 or 480 volts. Consequently, the utility company would benefit from improvement in power factor, and the customer would benefit from an increase in efficiency of motor operation and a reduction of feeder losses.

The power factor of most factory loads is less than 70 per cent when uncorrected. Figure 1 shows a set of performance curves for what is considered a typical motor. While they are shown as applying to a motor in the 220-volt class, they also apply to 440-volt motors. The power factor curve indicates that when the power factor is as low as 70 per cent and the voltage at the motor terminals is 220, the motor is operating at less than 25 per cent of rating.

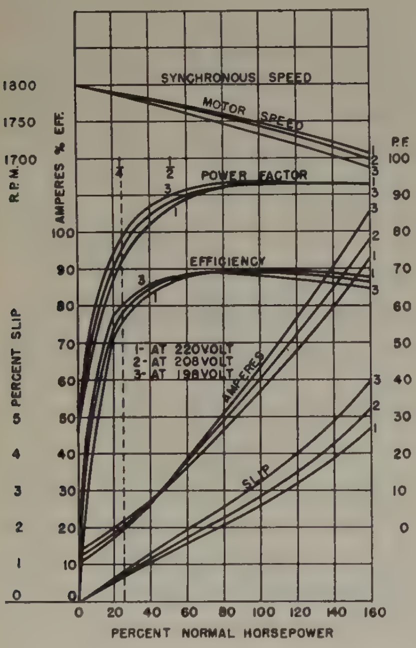

Figure 1. Performance curves for standard 220-volt motor

Table I. Motor Test Using Normal and Reduced Terminal Voltage

Voltage	Kilowatts	Kilovars	Per Cent Power Factor	Kilowatt-Hours Per 1,000 Pieces
492	8.90	13.0	56.2	103
440	8.60	9.2	64.9	99.5
Test results on a percentage comparison are as follows:				
440	Normal	Normal	Normal	Normal
492	3.5 per cent increase	41.3 per cent increase	8.7 per cent decrease	3.5 per cent increase

The 3-phase 4-wire system can be used for lighting without remote control, since the 250-volt limitation placed on general-purpose switches for lighting circuits by the Underwriters' Laboratories, Inc., is higher than the 240-volt phase-to-neutral potential on the suggested system.

Particular emphasis should be placed on special tests which were made on individual motors operating machine tools designed for a specific job and which the manufacturing superintendents had selected as being equipment which would be fully loaded. In none of these cases were any motors found that were carrying an average load above 50 per cent, and in most cases, the average load was much lower than 50 per cent of rating.

Table I gives in tabular form the performance of a motor driving a special continuous screw machine making commutator hubs. This particular motor was selected upon the suggestion of the factory maintenance engineer inasmuch as he felt sure the motor was fully loaded. The test first was made at their normal voltage and was repeated by reducing this voltage 10 per cent by means of a compensator. Note particularly that the power factor when operating at 492 volts was only 56.2 per cent, whereas when the voltage was reduced to 440 volts, the power factor was 64.9 per cent. Also note that the kilowatt-hours per 1,000 pieces were reduced from 103 at 492 volts to 99.5 at 440 volts. The motor was operating at an average load of only 30 per cent of its horsepower rating, and the maximum horsepower requirement, as indicated by the graphic record, was only 50 per cent of the motor rating. Had it been possible to reduce the voltage further, considerable improvements in both power factor and efficiency would have been realized.

In conclusion, attention is called to the fact that the 120/208-volt 3-phase 4-wire network system has been widely accepted and has proved very satisfactory. It should be obvious, therefore, that a 240/416-volt system for manufacturing plants also should be satisfactory, since universal use now is being made of low-impedance distribution feeders and distribution substations located at relatively short distances from each other.

Digest of paper 53-72, "240/416-Volt 3-Phase 4-Wire Power and Lighting Supply for Modern Industrial Plants," recommended by the AIEE Committees on Industrial Power Systems and Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Circuits for Carrier Trapping of Resonant Taps

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IN THE APPLICATION of carrier current to rural distribution lines, the problem of treatment of resonant taps is more acute than in similar installations on high-voltage transmission circuits. Large numbers of taps between 1/4 mile and 1 mile in length will be found on these lines. Taps of those lengths will be resonant at frequencies between 50 and 150 kc and in effect will short-circuit the carrier.

The high cost, complexity of installation, and maintenance problems associated with the conventional parallel-resonant traps or carrier chokes inserted in series with the tap makes their use impractical on distribution circuits. Use is made of the facts that a 1/4-wave stub whose far end is unterminated is equivalent to a short circuit while the same stub with the far end short-circuited, reflects an open circuit at the point of connection.

Connecting a series resonant circuit from line-to-ground at the far end of the resonant tap short-circuits it at the carrier frequency and raises the impedance at the tap-off point. Losses as high as 20 decibels or more may be eliminated or reduced to a negligible value.

In practice, on lines of 7.2 kv, the series resonant circuit used consists of a carrier coupling capacitor of 0.002 microfarad in series with a slug-tuned coil whose inductance varies from 0.5 to 3 millihenrys, depending on the frequency. The installation and tuning of this trapping equipment is inexpensive and simple. Figure 1 shows an installation of this type one span from the end of a single-phase tap resonant at 90 kc. By using a variable inductance in the series circuit the location of the trap is not critical and, when necessary, may be moved one or two spans from the tap end for convenience in installation. Figure 2 shows the slug-tuned coil and carbon-gap protector mounted in a weatherproof housing. The coil is designed to carry the capacitor current and is insulated for the maximum breakdown voltage of the carbon protecting gap. Since the coil is connected between the coupling capacitor and ground and has a maximum inductance of only 3 millihenrys, no additional drain coil is required.

Figure 1. Installation of carrier trap one span from end of single-phase tap

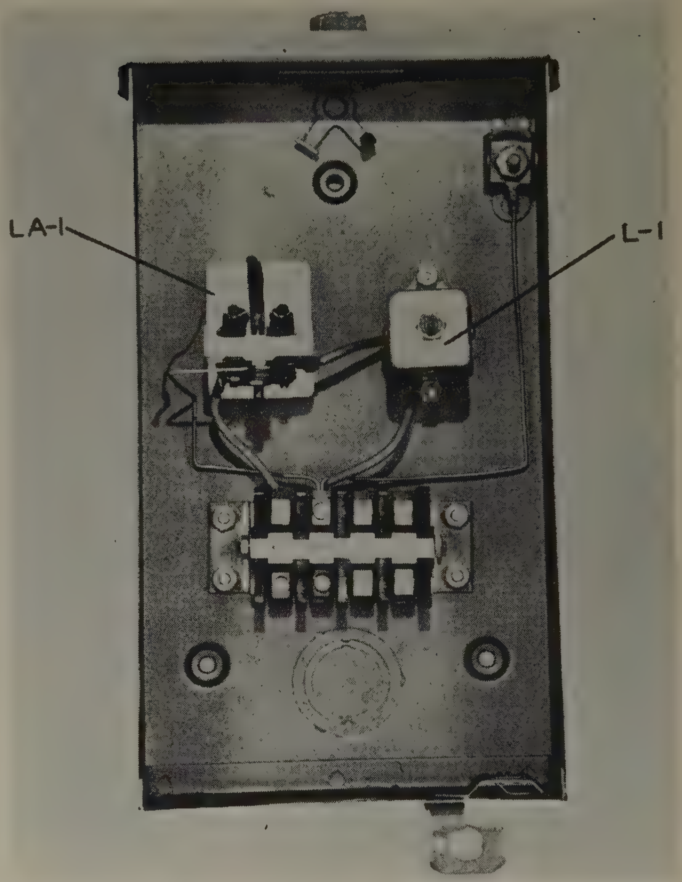

Figure 2. Slug-tuned coil for series resonant trap in weatherproof housing with carbon-gap protector and terminal board

A vacuum-tube voltmeter is connected to the main line through a coupling capacitor at or near the tap-off point and the coil at the tap end tuned for maximum voltage. On distribution systems with line-to-ground voltages up to 8.6 kv, connection of the vacuum-tube voltmeter to the line is made easily by means of a portable "hotstick" coupler which incorporates a coupling capacitor, series fuse, and drain coil in the insulated stick.

Digest of paper **53-204**, "Series Resonant Circuits for Carrier Trapping of Resonant Taps," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N.J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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The authors wish to thank Harold W. Kelley of the Technical Standards Division, Rural Electrification Administration, for the original suggestion which led to the development of the technique.

Forcing Function Generator Using Conductive Plastic

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ASSOCIATE MEMBER AIEE

THE LAST FEW YEARS have seen the field of servomechanisms develop into one of the leading branches of engineering. Along with this rise has come an increasing need for instruments to be used in this field. One of the most important of these instruments is the signal generator necessary to provide a forcing function signal to the servo system being studied.

The frequencies involved in testing servo systems vary from 0.001, or less, to 50 or 60 cycles per second and may be a sine wave or sine-wave-modulated a-c carrier. Because of the difficulties in electronic modulation at the extremely low frequencies, an electromechanical system usually is employed to obtain the desired forcing function.

A function generator employing some type of linear potentiometer or sinusoidal potentiometer seems to be the most desirable from a standpoint of reliability and simplicity. The sinusoidal potentiometer is ideal except for the problem of resolution and the possibility of excessive wear. One potentially attractive solution to these problems is the use of a conductive plastic potentiometer. It is well known that a wire-wound potentiometer made in the form of a square card can be used to produce sine wave electric signals with mechanical rotary motion input. However, the problem of resolution still exists. By substituting a homogenous piece of conductive plastic for the wire-wound potentiometer, the number of steps can be increased to infinity so that a stepless sine-wave signal is produced. To obtain a sine-wave signal, the plastic is connected as shown in Figure 1. However, the generator need not be limited to a sine-wave signal. By using other configurations of conductive plastic and/or metal, almost any periodic waveshape can be generated.

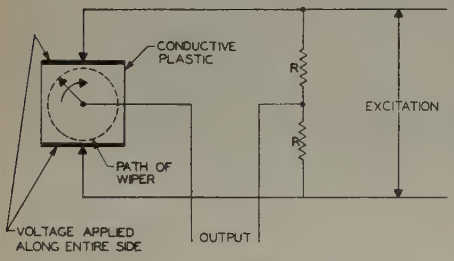

Figure 1. Method of connecting plastic for the generation of sine waves

Figure 2 shows the front panel of the function generator employing conductive plastic. The final design provides an output which varies in frequency from approximately 0.05 to 60 cycles per second. A 2-phase servomotor with built-in velocity generator, connected in a velocity servo system, is used as the driving motor. To obtain a frequency range of 1,200 to 1, it is necessary to provide two output shafts from the gear train of the motor, with provisions for manual shifting to allow selection of one or the other of the two speed ranges.

Since the majority of frequency response tests on servo systems require a measurement of phase as well as amplitude, a double-frequency sweep potentiometer and marker pip are provided within the function generator. The double-frequency sweep is connected to the horizontal plates of a cathode-ray oscilloscope and the marker pip is superimposed on the servo output waveform appearing on the vertical plates. By moving the position of this marker pip the phase may be read directly from a calibrated dial.

To help eliminate additional equipment, a-c and d-c excitation for the conductive plastic potentiometer are provided within the function generator. A frequency reading voltmeter is included also to make possible the quick determination of the forcing frequency.

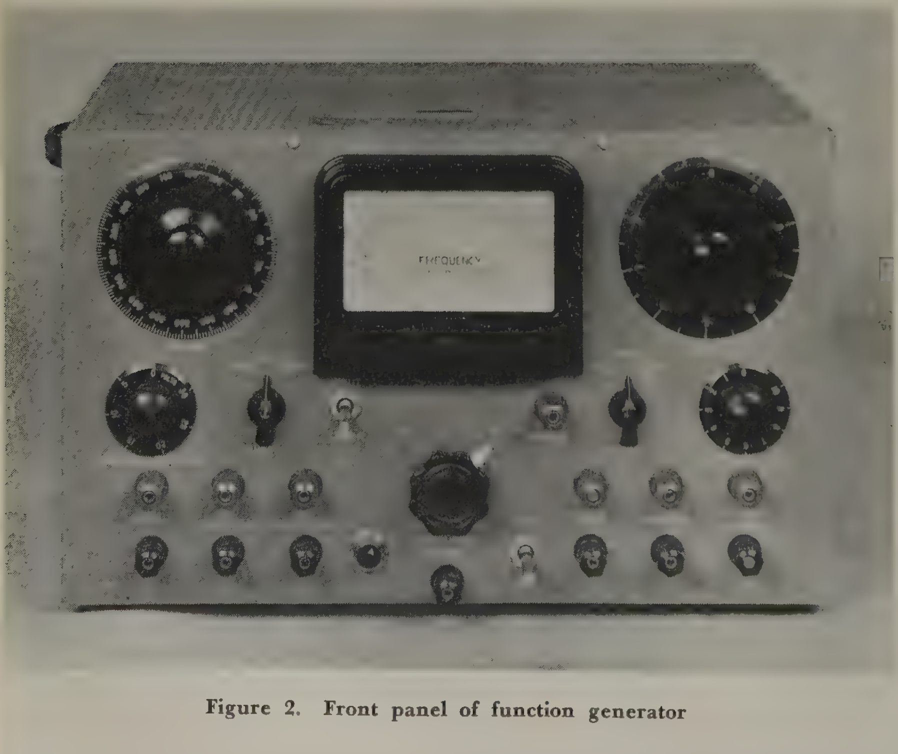

Figure 2. Front panel of function generator

Digest of paper **53-289**, "Forcing Function Generator Employing Conductive Plastic," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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Controlling D-C Arcs

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A METHOD OF CONTROLLING d-c power arcs is presented, with the emphasis on eliminating retrogressive motion of the arc. The data are applicable to interrupters which draw the arc in air and force it into an arc chute by means of a magnetic field. The arcs range from 50 to 20,000 amperes at 100 to 1,000 volts.

The key to arc control is an understanding of retrogression. This is sudden shortening, usually by the establishment of a parallel arc behind the main arc. The outer arc subsides and the new arc resweeps the arc runners and the arc chute. At the very least, retrogressions produce excessive erosion of contacts, of arc runners, and of arc chutes. Melts from preceding arcs during the interruption are blasted clean by the explosive action of the resweeping arc. Excessive retrogressions cause such frequent retracking along arc-running surfaces that the ability of these surfaces further to absorb thermal energy is diminished. When their thermal reservoirs are filled, the melts become excessively large in area. These in turn produce a breakdown of the gaseous dielectric, provide high stability of both arc termini, and a failure results. Some retrogressions result in current resurge. Resurges have been long observed on oscillographic records. A common type of retrogression which results in resurges is described by J. D. Cobine.[1] The type he describes occurs when the arc voltage becomes great enough to produce a spark breakdown across the shortest gap.

Retrogressions not identified by published information and not generally recognized are those which do not result in a change in the existing rate of current decay. Figure 1 shows six frames from a motion picture of an interruption which had a total of three retrogressions. The oscillogram of this interruption did not show current resurge. Note that the arc ends are between the same regions in frames *2* and *5*. Frame *4* shows the retrogression occurring from the existing cathode spot to the anode surface.

High-speed motion pictures, oscillograms, and arced surfaces were studied to learn the following. First: On a continuous metal surface the cathode end of the arc moves readily and smoothly.[2] Second: The anode end of the arc moves forward in steps.[2] Third: Discontinuity in a metal surface impedes travel of either arc end. Fourth: Uncooled melts, either cathode or anode, are hazards—particularly when there is little distance between melts of opposite charge. The ionization potential of metal atoms is about 8 electron volts. The ionization potential of atmospheric gas atoms is about 14 electron volts. Thus a gaseous region containing a high percentage of metal atoms will ionize much more readily than will a normal atmospheric gas. Fifth: Rapid current decay produces inductive voltages additive to the supply voltage.

A study of arc performance and characteristics indicates that the following should be done to mitigate arc retrogression. Make all arc-running surfaces as long and continuous as possible. Where gaps or irregularities are necessary, design them to promote streamline gas flow, thus providing quick transfer of the arc to the farther surface. Keep melts small by moving the arc ends continuously forward onto cool metal. The melts should be widely separated. This is obtained in the ignition area by a large contact gap. Since in the arc's traveling the first large melts occur on the contact ends, contacts should be so contoured that their surfaces diverge at a wide angle. The fixed contact should have at least twice the length of the moving contact so that its end will be far from the opposite potential. To keep positive inductive voltages low, the magnetic blowout field should be weak in the main body of the arc chute, although it should be intense in the ignition region.

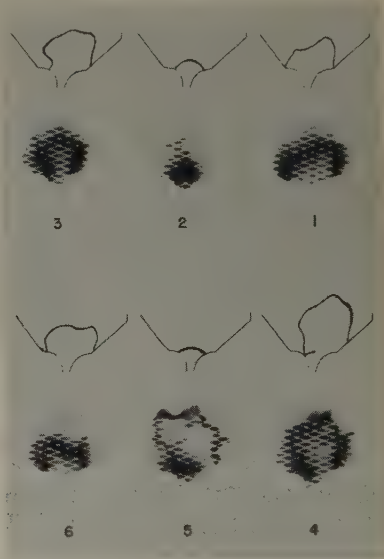

Figure 1. Stills from a high-speed movie showing a magnetic-blowout d-c arc interruption in air. Line voltage was 100 and peak amperes 1,450. Time is from right to left with the frames at 2,000 per second. Metal arcing surfaces are shown in the line diagrams above the frames. The right-hand surface was positive

The arc should be moved rapidly at first, slowly or not at all at last, smoothly at all times, and its metal runners should be as continuous as possible. If handled in such fashion, it will retrogress infrequently, it will do minimum damage to the interrupter, and its circuit will be given excellent protection.

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2. Arcs Between Moving Electrodes, **W. B. Kouwenhoven, T. B. Jones.** *Electrical Engineering*, volume 68, October 1949, page 834.

Digest of paper **53-264**, "Controlling D-C Arcs," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

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INSTITUTE ACTIVITIES

Number of Technical Sessions Increased to 92 for 1954 Winter General Meeting

Since the 1954 Winter General Meeting to be held in New York, N. Y., was first announced, the number of technical sessions being organized for the week of January 18–22 has been increased to 92. As this issue goes to press, the sessions are tentatively scheduled as follows:

January 18

Monday morning

Power Generation
Transmission and Distribution
Relays
Chemical Industry
Basic Sciences 1
Basic Sciences 2
Computing Devices
Medicine and Biology
Special Communications
Management

Monday afternoon

General Session

January 19

Tuesday morning

Marine Transportation
Rotating Machinery
Power Generation
Transmission and Distribution
Safety
Basic Sciences 3
Computing Devices
Electronic Power Converters
Production of Light
Telegraph Systems
Instruments and Measurements

Tuesday afternoon

Sections Committee
Rotating Machinery
Power Generation
Transmission and Distribution
General Industry Applications
Basic Sciences 4
Computing Devices
Nucleonics
Production of Light
Telegraph Systems
Instruments and Measurements

January 20

Wednesday morning

Wire Communications Systems
Heat Pumps
Rotating Machinery
Switchgear
Insulated Conductors
Industrial Power Systems
Electronics 1
Basic Sciences 5
Computing Devices
Land Transportation
Electrochemical Processes

Wednesday afternoon

Research
Rotating Machinery
Switchgear
Insulated Conductors
Industrial Power Systems
Electronics 2
Basic Sciences 6
Metallic Rectifiers
Land Transportation
Wire Communications Systems
Petroleum Industry

January 21

Thursday morning

Mining and Metal Industry
Rotating Machinery
Switchgear
System Engineering
Electronics 3
Basic Sciences 7
Basic Sciences 8
Television and Aural Broadcasting
Communication Switching Systems
Cathodic Protection

Thursday afternoon

Mining and Metal Industry
Rotating Machinery
System Engineering
Substations
Electronics 4
Basic Sciences 9
Basic Sciences 10
Television and Aural Broadcasting
Chemical
Insulated Conductors

January 22

Friday morning

Mining and Metal Industry
Rotating Machinery
Transformers
Carrier Current
Feedback Control Systems
Electronics 5
Basic Sciences 11
Magnetic Amplifiers
Television and Aural Broadcasting
System Engineering
Switchgear

Friday afternoon

Mining and Metal Industry
Rotating Machinery
Transformers
Feedback Control Systems
Electronics 6
Basic Sciences 12
Magnetic Amplifiers
Television and Aural Broadcasting
Switchgear

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and nearby hotels for members and guests attending the meeting. Requests for reservations should be sent prior to January 4 directly to the hotel of choice and to only one hotel. AIEE should be mentioned in the request and a copy sent to the vice-chairman of the Hotel Accommodations Committee, D. V. Buchanan, Room AU16, Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y. A second and third choice should be noted on this copy.

Due to the current accommodations situation in New York hotels, reservations for arrival on Sunday, January 17, are suggested. If the accommodations at the hotel requested are not available, the Hotel Accommodations

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Future AIEE Meetings

AIEE-IRE-ACM Eastern Computer Conference
Statler Hotel, Washington, D. C.
December 8–10, 1953
(Final date for submitting papers—closed)

Winter General Meeting
Statler Hotel, New York, N. Y.
January 18–22, 1954
(Final date for submitting papers—closed)

Scintillation Counters Conference
Washington, D. C.
January 26–27, 1954
(Final date for submitting papers—closed)

AIEE-IRE-ACM West Coast Computer Conference
Ambassador Hotel, Los Angeles, Calif.
February 11–12, 1954
(Final date for submitting papers—closed)

AIEE-IRE Conference on Transistor Circuits
University of Pennsylvania Auditorium, Philadelphia, Pa.
February 18–19, 1954
(Final date for submitting papers—closed)

Conference on Rubber and Plastics
Mayflower Hotel, Akron, Ohio
April 5–6, 1954
(Final date for submitting papers—January 7)

Southern Textile Conference
A. French Textile School of Georgia Institute of Technology, Atlanta, Ga.
April 15–16, 1954
(Final date for submitting papers—January 15)

Conference on Feedback Control
Claridge Hotel, Atlantic City, N. J.
April 22–23, 1954
(Final date for submitting papers—January 25)

AIEE-IRE-RETMA-WCEMA Electronic Components Conference
Washington, D. C.
May 4–6, 1954
(Final date for submitting papers—February 4)

North Eastern District Meeting
Schenectady, N. Y.
May 5–7, 1954
(Final date for submitting papers—February 4)

Appliance Technical Conference
Morrison Hotel, Chicago, Ill.
May 17–19, 1954
(Final date for submitting papers—February 19)

Electric Welding Conference
Milwaukee, Wis.
May 19–21, 1954
(Final date for submitting papers—February 19)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 24–26, 1954
(Final date for submitting papers—February 25)

Summer and Pacific General Meeting
Los Angeles, Calif.
June 21–25, 1954
(Final date for submitting papers—March 23)

Committee will transfer the request to one of the other hotels on the list.

Hotel rooms have been reserved at the following:

Hotel Statler (meeting headquarters), 7th Avenue, 32d to 33d Streets

Single room with bath	$ 6.00 to $11.00
Double room, double bed	8.00 to 14.00
Double room, twin beds	9.00 to 16.00
Studio type	15.00 to 18.00
Parlor suites	25.00 to 27.00

Hotel Governor Clinton, 7th Avenue at 31st Street

Single room with bath	$ 6.00 to $ 8.00
Double room, double bed	8.50 to 10.00
Double room, twin beds	10.00 to 13.00

Hotel McAlpin, Broadway and 34th Street

Single room with bath	$ 4.50 to $ 9.25
Double room, double bed	7.00 to 13.50
Double room, twin beds	8.50 to 13.50

New Yorker Hotel, 34th Street and 8th Avenue

Single room, tub and shower	$ 6.00 to $10.00
Double room, double bed	9.00 to 14.00
Double room, twin beds	10.50 to 16.00

Hotel Martinique, Broadway and 32d Street

Single room with bath	$ 4.50 to $ 7.00
Double room, double bed	8.00 to 11.00
Double room, twin beds	9.00 to 12.00

Hotel Commodore, 42d Street at Lexington Avenue

Single room with bath	$ 6.00 to $10.00
Double room, double bed	9.50 to 12.50
Double room, twin beds	11.00 to 15.00

Hotel Roosevelt, Madison Avenue at 45th Street

Single room with bath	$ 6.50 to $14.00
Double room, double bed	11.50 to 17.50
Double room, twin beds	13.50 to 20.00

Rates are subject to 5 per cent New York City hotel room tax.

THEATER TICKETS

As in the past, tickets to the following shows currently playing in New York will be available to all out-of-town AIEE members during the week of the meeting.

	Evenings	Wednesday Matinee
Cinerama	$4.00	$2.70
Kind Sir (comedy) Mary Martin, Charles Boyer	6.00	6.00
Wonderful Town (musical) Rosalind Russell	8.40	5.40
The Tea House of the August Moon (comedy) David Wayne, John Forsythe	6.00	4.80
Can-Can (musical)	8.40	6.00
Comedy in Music (revue) Victor Borge	6.00*	4.80
Dial M for Murder (drama) Maurice Evans	6.00*	4.80
The Seven Year Itch (comedy) Tom Ewell, Vanessa Brown	6.00*	4.80
My Three Angels (comedy) Walter Slezak	6.00	4.80
Picnic (drama, Pulitzer Prize) William Inge, Ralph Meeker	6.00*	4.80**
Rodgers and Hammerstein musicals		
Me and Juliet Isabel Bigley Joan McCracken	8.40	5.40
The King and I Yul Brunner	8.40	5.40
South Pacific Martha Wright George Britton	6.00	4.20

* $7.20 for Friday or Saturday.

** Thursday matinee.

All prices shown are brokers' prices.

Checks should be made payable to: "Theater Ticket Committee, AIEE." Requests also should include first and second choice of both name and date of show, and should be sent to: Theater Ticket Committee, AIEE, c/o S. Friend, Jr., Anaconda Wire and Cable Company, 25 Broadway, New York 6, N. Y.

Preference will be given in order of receipt to requests for seats in blocks of pairs and the committee reserves the right to reduce requests to sell-out shows to two tickets.

All ticket requests will be acknowledged promptly and refund will be made of any money due in excess of the price of tickets purchased.

Please do not include with theater ticket applications payment for any meeting fee or other item for which remittance should be made directly to Institute headquarters.

Tickets to available radio broadcasts and television shows also will be provided at the time of registration for the meeting.

SMOKER

The Smoker Committee, under the chairmanship of C. F. Bolles, announces that the smoker will be held on Tuesday evening, January 19, at the Hotel Commodore. Tickets are $10 each and include gratuities. Reservations should be sent to: Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Checks should be made payable to "Special Account, Secretary, AIEE." Reservations received after January 5 will not be honored.

DINNER-DANCE

J. G. Derse, chairman, has announced that the dinner-dance will be held on Thursday evening, January 21, 1954, in the Grand Ballroom of the Hotel Statler. Music and general arrangements will be the same as those which proved so enjoyable last year. Dress will be formal. Plan now and write soon for reservations at tables for ten. Tickets will be $12 each. Address requests to the Dinner-Dance Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Make checks payable to "Special Account, Secretary, AIEE."

LADIES' ENTERTAINMENT

The Ladies' Entertainment Committee, under the chairmanship of Mrs. E. S. Banghart, is planning a program of social events that should prove both interesting and enjoyable for the ladies. Registration will open Sunday, January 17, from 4 to 6 o'clock in the foyer of the Georgian Room, and from 9 a.m. on Monday, January 18, in Ladies Headquarters on the mezzanine. The "Get-Acquainted" Tea will be held on Monday afternoon. Among other events, such as a trip to the United Nations, a luncheon and fashion show at the Waldorf-Astoria, and sightseeing trips, there will be a dinner with entertainment on Tuesday evening (the night of the men's smoker) in the Penn Top. More details will be given in the January issue and in the mailed program.

Informal Tea

Inaugurated last year, this social gathering before the formal program begins was enjoyed by many members and guests. It is hoped that more will participate this year—on Sunday afternoon, January 17, from 4 to 6 p.m., in the Georgian Room of the Statler. There will be no charge.

During this same period the registration facilities will be open for those wishing to avoid the Monday morning rush.

INSPECTION TRIPS

The Inspection Trips Committee has plans under way for trips to the following points of general and special technical interest: Radio City Music Hall, International Business Machines Company, Federal Electric Products Company, Steinway Piano Company, Bell Telephone Laboratories at Murray Hill, N. J., Brookhaven National Laboratory, Long Island Lighting Company Generating Station, Electrolux Vacuum Cleaner Plant, United Nations Headquarters, and Lever House.

Complete details are scheduled for the January issue of *Electrical Engineering*.

COMMITTEE

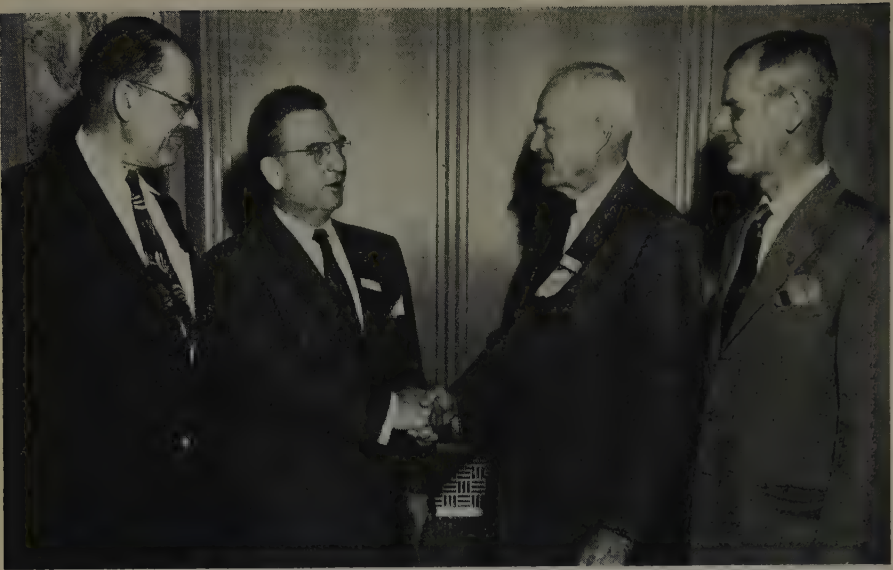
Members of the 1954 Winter General Meeting Committee are: C. T. Hatcher, chairman; A. J. Cooper, vice-chairman; J. J. Anderson, secretary; C. S. Purnell, budget co-ordinator; M. D. Hooven, Vice-President, District 3; L. F. Hickernell, chairman, Committee on Technical Operations; R. T. Ferris, publicity; L. F. Stone, general session; J. G. Derse, dinner-dance; D. E. Sullivan, inspection trips; C. F. Bolles, smoker; Sidney Friend, Jr., theater-radio-television; W. G. Vieth, hotel accommodations; H. E. Martin, registration; Mrs. E. S. Banghart, ladies' entertainment; R. T. Weil, monitors.

"Engineer and the Public" Is Timely Theme of Fall General Meeting in Kansas City

"What the Electrical Engineer Is Doing for the Public" was the theme of the AIEE Fall General Meeting, which was held at the Muehlebach Hotel, Kansas City, Mo., November 2–6, 1953. The 26 technical sessions covered a wide variety of timely subjects and were well received by the 950 members and guests who attended the meeting. The less serious side of the meeting—the stag smoker and the dinner-dance—were enjoyed by everyone and the ladies committee arranged a full program for members' wives.

Among the sessions which proved very popular with the members were the three pertaining to petroleum pipe lines, refining, and production; eastern and western mining; three sessions relating to electronics and television, and several sessions on different phases of the power field. There were five inspection trips so arranged that members could go on them at different times and so not miss any technical sessions.

One of the social highlights of the meeting was the AIEE–Kansas City Chamber of Commerce luncheon on Wednesday. AIEE



C. G. Roush (center) chairman for the Fall General Meeting, welcomes Elgin B. Robertson, AIEE President. AIEE Vice-President C. M. Lytle is at extreme left. Colonel William M. Talbot, Director of Warning and Communication, Federal Civil Defense Administration, guest speaker, is at extreme right

President Elgin B. Robertson was the guest speaker, his subject being "The Engineer and Your Life." In describing what the electrical engineer does which affects the average citizen's everyday existence, Mr. Robertson stated, "The ordinary citizen has no idea of what is back of his water, gas, and electric service. Furthermore, he has not the faintest idea of the part that the engineer has in it, with the possible exception of knowing that engineers are concerned with the building of dams. He has no idea of the part the engineer plays in the food he eats, the clothes he wears, and the other services he takes for granted. He does not associate engineers with such items as newspapers for instance. However, the newprint itself is a product of the chemical engineer, the presses are within the province of the mechanical and electrical engineer, the news-gathering services involve all sorts of electrical communications, and the delivery of the paper is a product of engineering whether delivery is by truck or by bicycle."

Mr. Robertson concluded, "I am sure that if each one of us in our daily lives would pause and notice all the scientific, mechanical, and electrical wonders about us, we might realize that the engineer is the man who made it all possible."

GENERAL SESSION

The general session of the 1953 Fall Meeting was opened by C. G. Roush, chairman of the General Committee for the meeting. He introduced the mayor of Kansas City, William E. Kemp, who welcomed the members to the community. Mr. Kemp was followed by Colonel William M. Talbot, Director of Warning and Communication, Federal Civil Defense Administration, whose subject was the "Important Role of the Entire Electrical Industry in Civil Defense."

It is known that the enemy has the means to attack any American city by guided missiles, or from the air with atomic weapons. The premise on which the Civil Defense Administration has based its program is that if people can be given sufficient warning of an impending attack and if they know what to do then, many lives will be saved.

The United States has the Air Defense Command and Civil Defense. Each has 11 centers in the country. From the 11 air defense centers, warnings can be distributed to 199 key centers over a 4-wire multiparty network of telephone lines at the end of which are sirens for warning the populace. It is estimated that by the end of 1954, $18 million will have been invested in these warning sirens.

Colonel Talbot told how the Bell Telephone System had increased its external exchanges in Washington, New York, and several key cities, so that if its present facilities were damaged, communications could be maintained uninterruptedly. Every service of radio—in police and fire departments, in taxicabs, in the power and oil industries—stands ready for emergency use. He described in detail how Conelrad functions and how 100,000 amateur radio operators have volunteered their services as standbys during Conelrad operation and for other communication work.

In the aim to provide a 2-hour warning to people, instead of the present 15-minute warning by sirens, several devices are under consideration. One of these alarm devices will function if the usual frequency of the power lines is raised from 60 to 62 cycles and another uses the 12th harmonic of the 60-cycle power lines. This 720-cycle current would pass all components of a power system and actuate a special device for setting off an alarm.

AIEE President Elgin B. Robertson, the final speaker, gave a report on Institute affairs. After reporting on the recent meeting in Paris of the engineering officials of this country and those of western Europe, he discussed the financial condition of the Institute which he described as excellent.

He expressed concern over the small number of Student members and appealed to his listeners to help the Institute by impressing on students how valuable AIEE membership will be to them in the future, reminding the members that the Institute's future depends on the present students.

Mr. Robertson commended the work of the Institute committee members who give so freely of their time. Their work and that of the Board of Directors has increased along with expanding membership which on October 1 was 47,249, and this expansion has brought up problems of the handling and presentation of technical papers which also have increased in quantity. Institute headquarters should be larger, and AIEE Treasurer Walter J. Barrett has a plan which should provide new quarters within the next few years.

A small step forward has been made toward professional unity. The AIEE membership has been polled on this subject, "But," Mr. Robertson remarked, "other people are not as sympathetic as they might be."

TECHNICAL SESSIONS

Insulated Conductors. Five papers with much valuable data were presented in this session with M. H. McGrath presiding. The first presentation by R. C. Rifenburg gave an engineering basis for determining the economic size of pipe and section lengths for pipe-type cable installations as well as the design for a new type of semi-stop joint. The author explained that in the past much too large pipe and too small sections had been used.

The second paper on submarine cables which was presented by Andrew Bodicky integrated a great deal of data from experience over a great many years which should prove invaluable to anyone considering this kind of an installation.

The third presentation by D. C. Hawley collected much valuable data from a number of operating companies on several different types of conduit, ducts, and power cables crossing bridges and viaducts. Operating experiences with some of these installations also were described.

Still another paper which was presented by W. N. McDaniel gave a method of analysis of annual variations of harbor, water, and earth temperatures. The data indicated that annual temperature variations in the earth below a slow-moving body of water as well as below earth exposed to air varied sinusoidally. The amplitude decreased and the time lag increased with increasing depth.

In the last paper, which was by L. Meyerhoff, valuable methods and formulas were given to determine the pipe losses in nonmagnetic pipe for several different configurations of cables within the pipes.

There was a great deal of discussion on each of the papers by well-known representatives of the cable manufacturers and prominent operating people which contributed important contemporary experiences.

Petroleum Production. In this session the economic aspects of electric oil well beam pumping as well as oil field transmission and distribution systems were thoroughly discussed.

The first paper was presented by T. L. Scott and he advocated slow continuous pumping as the most efficient method with the least trouble in the long run. Drip-proof motors were employed as they are advantageous under bad weather conditions. In conclusion the author stated that the selection of the most economical and efficient type of prime mover does not depend on general rules but rather upon a careful accurate evaluation of all of the cost factors such as investment cost, operating cost, and lost production due to down-time. He predicted that when all factors are better understood there will be an increase in electrification and less loss of prime mover time.

The second paper on oil field transmission and distribution systems which was prepared by J. R. Ashley was presented by F. R. Woerner. An experimental installation was described for island pumping where a dam had been built across the Colorado River and the electrification will be at 1,200 volts for the area. In conclusion it was stated that the installation was in support of interest in a higher secondary voltage and the author would like to have industry approval of such a voltage.

In discussion, many questions from the floor were answered by the authors and some of the discussion centered about the unwillingness of utilities to take the risk and extend lines to new leases for electric pumping operations without a contribution. The view was expressed by Mr. Steuve that the oil companies should obtain geological information on new leases, get together with the utilities who should take a little risk, and then more electric pumping would be installed.

Switchgear. Five papers were presented in a session on switchgear with R. L. Webb, presiding. The first paper, which was presented by W. R. Wilson, dealt with silver contact life when exposed to arcing and the presentation added materially to the technical data already available on this subject. The study included the effects of contact geometry, current, voltage, bouncing, velocity, and arc energy. The data should prove useful to other designers.

This was followed by the second paper which was presented by I. B. Johnson on the subject of voltage recovery rate requirements in high-voltage circuit breakers. These requirements were advanced to the year 1960. As determined from a transient network analyzer study, voltage recovery rates for the assumed system variations were shown to be from 5,200 volts per microsecond at 138 kv to 7,000 volts per microsecond at 330 kv.

The last three papers were presented as a group and treated the subjects of low-voltage air circuit breakers, air system accessories, and quality control programs for circuit breaker manufacture. The presentations were made, respectively, by V. N. Stewart, W. C. Mitchell, and K. G. Darrow. Most of the discussion by well-known designers and operating people centered about design details and maintenance considerations with the exception of a discussion by H. F. Harvey which considered the application of the new low-voltage air circuit breakers to merchant marine and naval vessels.

Industrial Power Systems. Three papers on power distribution systems for a natural gas plant, oil refineries, and the chemical industries were presented together with a demonstration of the advantages of the grounded industrial system in a session on Monday afternoon with D. M. Allison presiding. The papers were representative of practices in most southwestern industries.

The first paper on natural gas plant power distribution systems, which was presented by J. K. Howell, described the systems used to generate, transmit, and distribute electric power in various plants of the El Paso Natural Gas Company which spread across western Texas, New Mexico, and Arizona. The authors responded to questions from operating people in regard to the grounding of the neutrals on the 4,150-kva generators, the non-use of high-voltage motors, the economic justification for the plan of generation, and the reasons for the selection of 34-kv transmission for short distances. In regard to this last point, the loads indicated were not the ultimate loads and Mr. Howell added that the system was insulated for 69 kv because of the high altitudes and the reliability required.

Feedback Control Systems. The Monday afternoon session on feedback control was presided over by H. W. Corey, Allis-Chalmers Manufacturing Company.

Dr. T. J. Higgins, University of Wisconsin, presented a paper by himself and C. M. Siegel, University of Virginia, entitled "Determination of the Maximum Modulus, or of the Specified Gain, of a Servomechanism by Complex-Variable Differentiation."

By differentiating and setting equal to zero the transfer function, values of the maximum modulus, the frequency at which it occurs, and the gain parameter may be obtained without tedious computation.

"Backlash in Velocity Lag Servomechanisms," by N. B. Nichols, Raytheon Manufacturing Company, gave an analysis of the fundamental-component method for obtaining the response of second-order systems involving backlash, and showed its limits of accuracy.

Dr. T. S. Amlie, United States Naval Ordnance Test Station, presented "A General Theory for the Determination of the Stability of Multiple-Loop Servomechanisms," by himself and Dr. Higgins. A clarification of the stability concept a rigorous theory of general stability analysis of single-loop servo systems, and an extension of this theory to multiple-loop analysis for lumped-parameter systems were given.

"Bibliography on Feedback Control—Part III," was presented by title only, for discussion.

Electrical Techniques in Medicine. Five conference papers were presented at the session on electrical techniques in medicine and biology over which E. D. Trout, General Electric Company, presided. The first two papers, by F. E. Hoecker and P. N. Wilkkinson, were devoted to instrumentation for hospital isotope programs. Mr. Hoecker discussed Geiger tubes and scintillation devices and Mr. Wilkkinson talked about electronic counting instruments, both papers dealing with setting up a pilot laboratory at the University of Kansas where physicians and technicians could become acquainted with instrumentation of the isotope field.

G. G. Wiseman, University of Kansas, described a microphotometer using ultraviolet light for measuring acid within a cell's structure. Operation of the photomultiplier tubes used in this equipment were dependent to a great extent on the signal-to-noise ratio.

An automatic analyzing system of the concentration of anesthetic gases as administered to a patient was discussed by R. W. Krone, University of Kansas. A new 3-unit machine has been developed: one part of it measures the carbon-dioxide concentration by infrared absorption; the second determines the oxygen concentration by measuring the paramagnetic susceptibility of the mixture; and the third unit measures the per-cent concentrations of any two anesthetic gases in the presence of oxygen by finding the velocity of sound through the mixture.

The final paper concerned gaseous discharge phenomena: "An Investigation of Metastable Levels in Gaseous Discharge Tubes" by R. H. McFarland, Kansas State College. An electrodeless quartz envelope containing thallium and mercury was heated to two different temperatures. Pulsating 120-cycle light of 2,537 Angstroms was focussed on the quartz cell and absorbed by the mercury atoms, elevating them to an excited state of 486 electron volts. Through collisions between the mercury and thallium atoms, the latter were excited to about the same potential of 486 electron volts. The emitted light was measured by passing it through a grating monochromator (to select the desired wavelength), detecting it with a photomultiplier tube, amplifying it with a twin-T amplifier tuned to 120 cycles, and measuring the output with an audio voltmeter. Representative curves were presented showing the intensity of various thallium lines plotted against the temperature determining the mercury vapor pressure.

Petroleum Industry. Three sessions devoted to the petroleum industry were included in the program, these being devoted to pipe lines, refining, and production. A total of nine conference papers were presented in these sessions.

In the Tuesday morning session in which subjects relative to petroleum pipe lines were considered, V. J. Sittel, Service Pipe Line Company, presided. The opening paper, by R. J. Osburn, Sinclair Pipeline Company, "Selection of Motors and Controls for Pipe-Line Pumping Stations," was divided into three parts: large-diameter trunk-line stations using 800-horsepower motors and larger; smaller trunk and gathering stations using motors between 200 and 500 horsepower; and field pumps and stations using motors up to 200 horsepower. In each instance, the author discussed the motors' horsepower, speed and direction of rotation, voltage, number of phases, frequency and type of motor, and the type of motor enclosure. It was stressed that no single type of motor or control can be definitely designated as the one most suitable for pipe-line use, but factors such as initial cost, low operating expense, safety, maintenance, and so forth, will affect the selection of equipment.

"Remote-Controlled Pipe-Line Pumping Stations" by R. S. Cannon and T. V. Bockman, Plantation Pipeline Company, was presented by the former. This paper described the performance of four unattended pumping stations and their cost. Two stations are remote-controlled by microwave radio and two are controlled over circuits leased from the telephone company. As either system gives sufficiently reliable results for pipe-line operation, the main factor is one of economics. Microwave radio, depending on the number and type of channels, type of construction, local terrain, and so forth, will cost annually between $15 and $24 per mile per month, including depreciation and maintenance. Interstate rates of leased telephone circuits are about $1.50 per mile per month for teletype and $3.00 per mile per month for voice-frequency-type circuits. It was brought out that the latter could be multiplexed into 12 to 16 telegraph circuits at a low cost and quite a few channels for remote-control functions could be had from each voice-frequency circuit.

The final paper, "Petroleum Microwave Progress—1950–54," was given by E. B. Dunn, The Atlantic Refining Company, in which was traced the progress made in the use of radio equipment for petroleum pipe-line control and communication from the 70-mile Keystone Pipe Line System (November 1949) to the 540 stations of today covering 13,200 system miles. This represents an investment of about $17 million.

Safety. On Tuesday morning, a session on safety was held with C. E. Ganther, Cleveland Electric Illuminating Company, presiding.

C. C. Stoltz, Westinghouse Electric Corporation, presented "Electrical Safety in a Large Development Laboratory," coauthored by G. L. MacLane of the same company. The prime requirement in developing a safety program is the careful indoctrination of laboratory personnel, who are not only exposed to electrical hazards, but those of high-intensity arcs, burns, and explosions. A safety committee, safety observers, and protective devices are all necessary to maintain an adequate safety program.

"Safety in the Utilization of Electricity on the Farm" was discussed by E. H. Smith, Kansas City Power and Light Company. The safety problem peculiar to rural areas is caused by inadequate wiring, grounding, and lighting, insufficient insulation in damp and corrosive atmospheres, and improperly installed infrared heat lamps, coupled with a lack of appreciation by the farmers of the power inherent in electricity. They must be made to realize that specialized knowledge is needed to install and repair electric equipment, as they are used to doing all tasks around the farm themselves.

C. R. Zeskey, T. H. Mastin Company, emphasized the appalling waste caused by accidents in industry in his paper, "Cost Control by Accident Control." Two million industrial accidents occurred in 1952, resulting in 15,000 deaths, at a loss of 250,000,000 man-hours, and $2,900,000,000. This monetary loss was second only to that caused by strikes and wage disputes. Engineers must become more interested in the vital subject of their own plant's safety.

A motion picture and demonstration was featured by A. L. Riche, Minneapolis-Honeywell Regulator Company, in "Precision Switches Used as Interlocks and Limits in Safety Controls." Numerous examples showed how these tiny switches can control and protect workers and their machines at little cost. Over 6,000 types of mercury and mechanical precision switches are available to industry, which can perform or prevent almost any combination of operations to speed up and make safer production processes.

Management. A management session was held on Tuesday afternoon, F. K. McCune, General Electric Company, presiding.

P. F. Drucker, consultant, presented "How Should a Manager Spend His Time?" Although no set patterns are apparent in the habits of good time managers, they seem to distrust panaceas and devices such as uniformly fast reading, reports held to one page in length, and so forth, except where such methods are the most time-conserving. Good time managers spend much time on planning, little on actual doing, much on communications "up" (from subordinates and to superiors), much on defining a problem, little on solving it, and depend on the built-in sales appeal of their ideas, rather than the actual selling of them to others.

"The Implementation of a Management Development Program" was given by L. A. Russ, Westinghouse Electric Corporation. This company's program of seeking out and training potential managers was described. By means of guided rotation and management training programs, a reserve is built up on various levels of responsibility. The ensuing discussion raised the question of what effect such early selection of managers would have on those rejected, and indicated that many companies, especially small ones, feel that the morale problem caused by such programs may be paramount.

Aural and Television Broadcasting. The four papers presented at the session on aural and television broadcasting evoked enthusiastic discussion from the large audience. Professor R. G. Kloeffler, University of Kansas, presided.

F. A. Slaymaker, Stomberg-Carlson Company, in his paper, "Design, Principles, and Fallacies in the Hi-Fi Field," cleared up many questions which evidently had long gone unanswered for most of his audience. The long-playing record was one of the foremost factors for the increasing popularity of high-fidelity record players—those records and the medium-priced variable reluctance pickups. He showed a family of frequency-response curves (based on the familiar Fletcher curves) for the hearing of different groups of people and then interpreted the cutting characteristic curve by which recording companies are guided in producing records.

Mr. Slaymaker in the course of his paper demonstrated the effects of cutoff of the high and low frequencies in a good audio amplifier, leaving only the sound from 300 to 3,000 cycles. The chairman deferred the discussion of this paper until the end of the session and the wisdom of this move was evident because Mr. Slaymaker still was answering questions and demonstrating his answers more than an hour after the final paper had been read.

A. P. Walker, National Association of Radio and Television Boradcasters, explained the precautionary measures which can be put into operation to confuse enemy airplane navigators, in his paper, "Development and Practical Considerations of the Conelrad System for Standard Broadcast Stations." After explaining the underlying principles of the Conelrad system, Mr. Walker described the tests recently completed around New York City which had been received satisfactorily by broadcast listeners but had made orientation of an aircraft by the radio automatic direction finder extremely difficult.

The only technical paper of the session, "Development of Television Service Standards and Application to Design of a Television Broadcast Network," was given by O. W. B. Reed, Jr., of Jansky and Bailey, Inc. After reviewing the allocations of frequencies by the Federal Communications Commission and the distribution of the approximately 500 television transmitters throughout the country, the author, using Iowa as an example, showed how optimum distribution of transmitters could be effected.

The final conference paper of the session, "Factors Affecting the Correlation of Television Picture Quality Between Field and Laboratory Signals," was given by B. Amos and C. Quirk, Du Mont Corporation, and read by the former. After explaining the difference in laboratory test signals and those broadcast from a transmitter in the field, the speaker described the various circuits of a television receiver, their individual gains which are necessary for field operation, and how they must be adjusted under laboratory and production test conditions to function successfully in the field.

Television. Four conference papers were presented in the Wednesday morning session devoted to ultrahigh frequency and television over which G. R. Town, Iowa State College, presided. The first was by W. Y. Pan, RCA Victor, who discussed ultrahigh-frequency amplifier operation.

Several factors caused very-high-frequency transmission and reception to be superior to those of ultrahigh frequency, among them being cosmic and man-made noises, wave absorption coefficient, antenna wavelength factor; receiver antenna gain; and the receiver noise figure. The only one which is controllable is the noise figure and this might be improved by using a radio-frequency amplifier stage ahead of the mixer.

Mr. Pan reviewed the several tube types—planar, cylindrical, miniature—with respect to their use in a receiver and their cost and the conclusion was that miniature tubes must be made more stable or other tube types must be made cheaper in order to get a good radio-frequency amplifier.

G. H. Brown, RCA Laboratories, presented "Review of Development of Color Television" from 1940 up to the present, explaining to his audience how the National Television System Committee came into being and the excellent work this group had done in determining what color-television standards should be recommended to the Federal Communications Commission for its adoption.

"Beat Between Sound Carrier and Color Signal in a Television Receiver" was given by J. E. Allen, General Electric Company. In the course of television field tests, it has been found that receivers need about 50 decibels of sound attenuation in the intermediate-frequency channel in order to prevent beats between the sound-carrier and the color-carrier components from appearing in the receiver. A study of this has shown that such sound rejection is usually needed in an ideal receiver having the standard selectivity curve. The calculated attenuation is 44 decibels, which, because of transmission and other variations, points to the use of at least a 50-decibel sound trap.

The last paper of the session, "Unified

Signal Coder for Compatible Color Television System," was by J. F. Fisher and A. J. Anderson, Philco Corporation, and read by the former. A description was presented of the encoder which is a device which gathers the three color signals and feeds them to the input of a transmitter.

Radio Communication. Three technical papers and one conference paper were given in a session on radio communication over which E. D. Nuttall, United Gas Corporation, presided.

The subject of the first technical paper, which was re-presented for discussion, was "A Miniature Compandor for General Use in Wire and Radio Communication Systems" by F. S. Boxall and R. S. Caruthers, of the Lenkurt Electric Company, Inc. This paper consisted of a description of how a compandor functions in an open-wire, cable, or radio channel, and the physical components of a plug-in compandor with a 2-to-1 compression and expansion characteristic.

"Use of Radio and Radar in the Petroleum Industry" by W. M. Rust, Jr., Humble Oil and Refining Company, traced the history of the use of radio from 1925 by oil companies on their tankers. In 1932, a few oil companies began to use radio in Louisiana swamps for communicating between drilling rigs and base offices. Radio facilities are required for geophysical operations: for co-ordination of activities, which may be separated by several thousand feet or 10 or 12 miles; the transmission of special data; and the determination of position by radiolocation means. Radio also is used in pipeline communications and control and for communications within refineries. The use of radar as a navigation aid to tankers, as a harbor surveillance device, and as an aid in detecting line squalls or hurricanes, has proved invaluable. In June 1952, there were 553 users of radio in the petroleum field which requested recommendations for frequency assignments for 21,400 transmitters.

The third technical paper, "Microwave as Applied to Railroad Operation in the Gulf Coast Area" by L. R. Thomas, is a description of the installation, operation, and the maintenance of a 70-mile microwave relay system in Texas with particulars on the means taken to overcome the problem of fading, especially on the over-water links in the network.

Victor Nexon, Microwave Services, Inc., read the conference paper of the session on the need for "Industry Co-ordination of Microwave Communication Systems." Because of the rapid growth of the use of microwaves in industrial communications, interference is becoming more of a problem especially in those areas in which several systems are concentrated as in the vicinity of large cities. The speaker detailed the needs of this form of communication and recommended that a joint microwave commission group be formed for the best interests of all groups of users.

Eastern Mining. Eastern mining was discussed in a Wednesday morning session, under the chairmanship of R. B. Moore, General Electric Company.

A. J. Stone, I-T-E Circuit Breaker Company, presented "Protective Devices Underground." Safety cannot be overemphasized in mining; it is the responsibility of the engineer to bring to the attention of management a proper plan for the adequate protection of their electric circuits. Protection should be included in the budget as part of the over-all investment.

P. C. Cross, General Electric Company, gave "The Underground Electrocarbonization of Coal," which was coauthored by Dr. E. Sarapuu, Sinclair Coal Company. Underground electrocarbonization can yield gas which, converted to electric energy at the site, may cost only a fraction of the money necessary to mine and transport coal by conventional methods. Analysis of a proposed large-scale industrial installation indicates that a cost of only 10 cents per 1,000,000 Btu may be expected.

The "St. Joseph Lead Company Development at Indian Creek," by E. H. Tucker, of this company, and D. E. Cain, General Electric Company, was given by Mr. Tucker. A lead-zinc ore-processing plant, minimizing labor requirements and using the latest equipment, has been constructed. Electric equipment was selected to take full advantage of completely manufactured units. The main-power, underground-power, and surface-distribution systems, as well as hoist, compressor, crusher, mill, and flotation equipment, were discussed.

Western Mining. J. G. Ivy, International Minerals and Chemical Corporation, presided over the Wednesday afternoon session on western mining.

F. C. Dohaney, Canadian General Electric Company, presented a paper, "A 6,000-Horsepower Automatic Mine Hoist Drive," by himself and L. W. Fisher, of the same company. Within the last 4 years, a Canadian mine has added 24,000 horsepower in amplidyne-controlled adjustable-voltage mine-hoist drives to its vertical transportation system.

"Electric Equipment of Electrolytic Zinc and Copper Production," was given by C. P. Clark, General Electric Company. The selection of conversion equipment for electrochemical processes must be reviewed regularly. The rotary converter, once the standard of rectification for electrochemical use, has yielded to the mercury-arc rectifier, in high-voltage applications, and to the motor generator and mechanical rectifier in low-voltage use. In the future, the germanium power rectifier should find increasing acceptance in the low-voltage field, as it is capable of 94-per-cent efficiency.

"Arc Furnaces in Mining Industry," by W. G. Wright, Canadian General Electric Company, was presented by Mr. Dohaney. The trend in modern furnace practice to the use of the electric arc for the production of ordinary-grade steels was noted, and electric equipment used, including switchgear and transformers, was discussed. Arc characteristics were described and methods of regulation detailed.

Other equally important sessions held during the latter part of the meeting could not be included here as the closing date for material occurred during the middle of the meeting. These sessions were on subjects as follows: cathodic protection, transmission and distribution, power generation (two sessions), computing devices (three sessions), transformers, protective devices, system engineering (two sessions).

COMMITTEES

The members of the General Committee for the 1953 Fall General Meeting were G. C. Roush, chairman; Riley Woodson, vice-chairman; S. H. Pollock, secretary-treasurer; C. M. Lytle, Vice-President, District 7; J. C. Bibbs, J. E. Barfield, O. H. Johnson, C. M. Haynes, members-at-large. The subcommittee chairmen were J. P. Kesler, registration and hotel; William Carter, reception; L. M. Schindel, technical program; R. L. Baldwin, finance; A. C. Kirkwood, entertainment; H. E. James, inspection trips; M. J. Horney, publicity; L. L. Davis, transportation; O. L. Starcke, printing; W. P. Smith, students; Mrs. S. H. Pollock, ladies.

Future Airplane Electrical Design Forecast at Aircraft Technical Conference

With an attendance of 382 engineers from all parts of the United States, the AIEE Aircraft Technical Conference was held in Seattle, Wash., September 30–October 3, at the Benjamin Franklin Hotel. A feature of the meeting was the inspection trips to the Boeing Airplane Company and Ault Field. On the latter tour, most of those attending took a trip on a *DE* Destroyer Escort ship. However, 40 of the aircraft engineers took advantage of transportation on a Boeing *C-97* Stratofreighter provided by the Air Force.

For the first time at a technical conference, many of the papers were officially presented as *Transactions* papers. This was made possible by the co-operation of members of the AIEE Headquarters staff and the AIEE Committee on Technical Operations. Of the 34 papers presented, ten had *Transactions* status.

For the benefit of engineers who could not leave work to attend daytime sessions, two sessions were held in the evening.

Many technical papers which will set the course for airplane electrical design for many years into the future were presented. Lee R. Larson, Naval Research Laboratory, concluded in one paper that modern aircraft should use systems with parallel generators; and that the generators should be alternating current. He suggested that as a design objective, the a-c system should be made as simple to operate as the old d-c systems, which would mean fully automatic paralleling.

Cooling electronic equipment in airplanes by sucking rather than blowing was advocated by R. E. Hedges, Douglas Aircraft Company. He told about experiments where squirting more and more air around electronic black boxes did not make the components run much cooler. However, when a hole was cut in the black box and air sucked out of it with a venturi, it was found that condensers and other components operated at 30 to 50 degrees cooler with only 30 pounds of cooling air per hour. Furthermore, the radiant heat to the crew's compartment was almost completely removed.

Mr. Hedges noted that a modern airplane carries too many audio amplifiers for the number of microphones it has. He suggested that considerable systems engineering for communications equipment was in order.

Another significant paper was entitled "Selection Factors for Jet Transport Electrical Systems," and was presented by E. P. Buckthal and Edward M. Haynes of the United Air Lines.

A. M. Johnston, veteran test pilot and Chief of Flight Test of Boeing Airplane Company, and speaker at the evening banquet held on September 30, traced a typical mission in a *B-52* Stratofortress to show how, at each stage, electrical failure could abort the mission. He stated, "Electronic equipment of modern high-performance airplanes is one of the life-giving arteries of that vehicle."

Before take-off electronic controls have to maintain cool temperatures in the cabin because the crew is dressed in heavy clothing. During take-off electric controls operate flaps and landing gears. During flight, failure of radio equipment would prevent establishment of an in-flight refueling rendezvous, and thus terminate the mission.

Interphone failure is serious because high-altitude survival equipment renders crew members almost immobile, Mr. Johnson explained. Since the "diving-type" helmets make verbal communication impossible, the crew has to resort to note-passing.

Failure of the navigational computer over water almost certainly would terminate the mission, he forecast. For some of the other components spare units are carried, but during the half-hour spent in correcting a trouble the airplane has flown 300 miles, and could be so far off course that there would not be enough fuel to complete the mission and return home.

During the bombing run, electric equipment used to open bomb doors and release bombs must function dependably. In the event the airplane is punctured, it loses cabin pressurization. After that, the crew can survive only 10 minutes unless the plane is dived to a lower altitude, Mr. Johnston said. Flight at lower altitude results in higher fuel consumption, which in a critical mission can make the return to home base difficult.

Mr. Johnston compared the *B-52* with a *DE* Destroyer Escort vessel, both of which are in the same price class. The *DE* has a crew of some 150 men, whereas the *B-52* has five. Yet both vehicles move about in a fluid and have similar problems. However, the *DE* has extensive repair facilities, spare parts, and spare personnel, while the *B-52* is dependent on the reliability of its equipment.

"The *B-52* carries more fuel than has ever been air-borne in one vehicle before," Mr. Johnston noted. "Fuel management is extremely important because having too much fuel in the wrong place can displace the center of gravity so far that the airplane becomes uncontrollable. The electronic equipment used in fuel quantity gauging must not give false readings."

PROCEEDINGS

Copies of both the conference and technical papers have been made available as a Special Publication on this basis:

S-57	Conference papers only	$3.50
S-57	Conference papers and technical papers (468 pages)	4.00

A pamphlet of the discussions is expected to be made available at a price to be announced later.

Shown at the speakers' table during the Aircraft Conference banquet are (left to right): Mrs. A. M. Johnston; Test Pilot A. M. Johnston, speaker; John Nelson, chairman, Seattle Section; W. M. Allen, president, Boeing Airplane Company; Mrs. T. J. Martin; T. J. Martin, conference chairman; L. R. Larson, vice-chairman; Committee on Air Transportation; R. J. Helberg, chairman, banquet committee

Shown at the recent Aircraft Conference are, left to right: T. J. Martin, chairman of the conference; A. M. Johnston, test pilot who spoke at the banquet; and L. R. Larson, vice-chairman, Committee on Air Transportation

District 2 Student Activities Committee Holds Annual Meeting in Washington, D. C.

The Student Activities Committee of District 2 of the AIEE held its annual fall meeting at Howard University, Washington, D. C., on October 16 and 17, 1953. Representatives from 22 of the 28 schools in this District were present.

Following registration on the morning of the 16th, separate conferences of students and counselors were held. At the student conference, which was presided over by James R. Duncan, chairman of the Howard University Branch, Dr. L. K. Downing, dean of the Howard University School of Engineering and Architecture, gave a brief talk in which he welcomed those attending the conference to Howard University. There was a discussion of Branch organization and operation, program planning for Student Branches, use of Branch allowances, and the student prize paper competition. Herman F. Lame, a noted civil engineer, addressed this group on professional registration of engineers. Frank E. Martin, District 2 vice-chairman, AIEE Membership Committee, addressed this group on increasing student membership in AIEE and advantages of continuing membership in AIEE as associate member after graduation.

COUNSELORS' CONFERENCE

The conference of counselors was presided over by Ernest R. Welch, chairman of the District 2 Committee on Student Activities, who opened the meeting with a brief report on the meeting of the Committee on Student Branches at the Summer General Meeting in Atlantic City in June 1953, and a brief report on the 1953 District 2 prize paper contest which was held at Bucknell University. Walter B. Morton, Vice-President of District 2 then gave a report on AIEE Student Branches. Professor K. F. Sibila, University of Akron, led a discussion of Student Branch and District prize paper competitions. Out of this discussion came a recommendation that the scoring system for grading of papers be reviewed with the thought that a different method might encourage greater student participation in prize paper contests. Professor Carl F. Evert, University of Cincinnati, invited the group to hold its 1954 District Prize Paper Contest at the University of Cincinnati. This invitation was accepted and the 1954 District Prize Paper Competition will be held at the University of Cincinnati at a time to be selected by Professor Evert. Professor Neal A. Smith, Ohio State University, invited the group to hold its 1955 Prize Paper Competition at Ohio State University in conjunction with the District 2 meeting which is scheduled for Columbus in 1955. This committee received with thanks the invitation and decided to recommend to the Student Activities Committee which succeeds this one that the invitation be considered, since this committee felt that it did not have authority to set a place for the 1955 District Prize Paper Competition.

An announcement was made of the invitation of Radio Corporation of America (RCA) to first, second, and third place winners in the District Prize Paper Competition to visit its laboratories as guests of RCA. There was a brief discussion of joint AIEE–Institute of Radio Engineers (IRE) activities with special emphasis on the joint AIEE-IRE prize paper competition. An announcement was made of the new allowance of $1.00 per member on rolls of the Institute on November 15 and $.50 per member for those joining between November 15 and February 1, emphasizing that there are no restrictions on use of this money but that a report of its use must be made to national headquarters. Ways of getting new members in the Branch were discussed. Professor E. C. Dubbe, West Virginia University, invited the Student Activities Committee to hold its 1954 annual meeting at the University of West Virginia. This invitation was accepted and Professor Dubbe was elected new chairman of this committee for the year beginning August 1954.

INSPECTION TRIP

At 12:30 p.m., the party boarded busses at the Engineering Building which had been provided through the courtesy of the Naval Ordnance Laboratory at White Oak, Md., for an inspection trip to that organization. A very interesting and educational inspection tour of the facilities of the Naval Ordnance Laboratory was made, covering the many laboratories.

DINNER MEETING

Friday evening was devoted to a dinner meeting in the Faculty Dining Room of Baldwin Hall, on the Howard University campus. After dinner, the group was welcomed by Dr. L. K. Downing for the university. Gravatt G. Coleman, chairman of the Washington Section, welcomed the group for the Washington Section. Walter B. Morton brought greetings from the District and introduced the speaker of the evening, Dr. Ralph D. Bennett, technical director of the Naval Ordnance Laboratory, who spoke on "Technology and Our Navy Today." Among the guests were T. A. O'Halloran and D. S. Bender of the Washington Section Advisory Board, W. J. Ellenberger, vice-chairman, and Myron M. Moore, secretary-treasurer of the Washington Section, Frank E. Martin, Dr. A. J. Blackburn, dean of students, and H. A. Ryan, dean of men of Howard University.

District 2 Student Activities Committee, Howard University, Washington, D. C., October 16, 1953

SATURDAY SESSION

At the Saturday morning session, Dr. Mordecai W. Johnson, president of Howard University, welcomed the group to Howard University. N. S. Hibshman, Assistant Secretary of AIEE, then addressed the group and answered questions from the floor abou Institute matters, and H. H. Sheppard District 2 Sections Committee representative who addressed the group, asked question about how Sections might better hel Branches and answered questions from th floor. Vice-President Morton addresse the group on Institute matters. Professo Sibila reviewed the subject of Branch an District Prize Paper Competitions for th group, and Mr. Martin summarized hi address of Friday morning pertaining t membership in AIEE and its advantages The District 7 Branch Manual was presented to this group and, after discussion a motion was passed recommending tha the Committee on Student Branches b asked to take necessary steps to have suc a Student Branch Manual distributed on national basis. The committee felt tha with a few minor changes to adapt thi manual to different Districts, such a manua would be excellent for use as a guide i Branch operation. There was an inspectio tour of the facilities of the new Engineerin Building at Howard University followin adjournment.

Board of Directors Meeting Held in Vancouver, Canada

The regular meeting of the AIEE Board of Directors was held in the Hotel Vancouver, Vancouver, British Columbia, Canada, on September 3, 1953.

The minutes of the meeting of the Board of Directors held on June 18, 1953, were approved as previously distributed.

EXECUTIVE COMMITTEE

Executive Committee actions on membership applications were reported and co firmed, as follows: As of July 31, 1953– 76 applicants transferred and 9 elected t grade of Member; 1 Member reinstate 2 Members re-elected; 357 applican elected to grade of Associate Member; Associate Member reinstated; 22 Associa Members re-elected; 39 applicants electe to grade of Affiliate; 164 Student membe enrolled.

The Board voted to approve the action of the Executive Committee approving the proposed changes in the second revision of the Standards manual.

BOARD OF EXAMINERS

Recommendations adopted by the Board of Examiners at a meeting on June 18, 1953, were reported and approved. The following actions were taken, upon recommendation of the Board of Examiners: 44 applicants transferred to grade of Member; 184 applicants elected to grade of Associate Member; 17 Associate Members re-elected; 43 applicants elected to grade of Affiliate; 62 Student members enrolled.

The Board of Examiners submitted 7 proposals for transfer to the grade of Fellow with a favorable recommendation and a recommended citation in each case. The Board of Directors voted to invite the 7 Members listed below to be transferred to the grade of Fellow:

E. F. W. Beck, Section Manager, Westinghouse Electric Corporation, East Pittsburgh, Pa.

C. H. Cramer, Assistant Transmission Research Engineer, Western Union Telegraph Company, 60 Hudson Street, New York 13, N. Y.

O. T. Farry, Supervisor of Power Transformer Engineering, Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis 14, Mo.

J. D. Ferguson, Managing Director, MacEntee and Ferguson Ltd., 28 Merrion Square, Dublin, Ireland

A. P. Godsho, Engineer of Transmission and Protection, The Bell Telephone Company of Pennsylvania, 1401 Arch Street, Philadelphia 2, Pa.

Glen Ireland, Vice-President Personnel Department, The Pacific Telephone and Telegraph Company, 140 New Montgomery Street, San Francisco 5, Calif.

D. W. McLenegan, Manager, Technical Personnel and Education, General Electric Company, Nucleonics Division, Richland, Wash.

More information regarding the aforenamed individuals appears under "AIEE Fellows Elected" (pages 1128–30).

FINANCES

Treasurer Walter J. Barrett submitted report for the period May 1 to July 31, 953, copies of which were distributed. The Board voted to accept this report.

Chairman Purnell of the Finance Committee reported disbursements from general unds as follows: July—$99,576.89; August —$79,175.32. The report was approved.

A comparative statement of income and xpenses for 11 months of the budget year nding September 30, 1953, was presented. t showed that the income to August 25 was $1,055,196, or 95 per cent of the estimated income for the appropriation year, nding September 30, compared with 92 per cent last year. Expenses for the 11 months ended August 31 were $996,284, or 86.5 per cent of the estimated expenses for the appropriation year, compared with 2.5 per cent last year.

OTHER BUSINESS

Upon recommendation of the Committee n Constitution and Bylaws, the Board dopted the following amendments to the ylaws:

Section 2. Amended by the addition of a aragraph as follows:

"Proposals for the election of Honorary Members all not be deemed to come under the review of the Board of Examiners and the routines set up by the Board of Examiners shall not apply to the nominees proposed for the grade of Honorary Member. In consideration of such proposals, the Board of Directors may use the assistance and advice of the Advisory Committee on Honors."

Add the following new section to the Bylaws as Section *67b:*

"The advisory Committee on Honors shall consist of six Fellows, appointed by the Board of Directors; six to be appointed initially with two each for 1-year, 2-year, and 3-year terms, and thereafter two to be appointed each year for a term of 3 years, all terms being from August 1st of the year in which they are appointed. This committee is charged with the continuing function of reviewing potential nominees for honorary membership, including suggestions that may be received from the Board of Examiners and others, and of recommending to the Board of Directors, candidates for election to honorary membership. This committee is not to be listed in the published list of standing committees."

Delete the first three paragraphs in Section *23* of the Bylaws and replace the deletion with the following:

Sec. 23. During September of each year, the secretary of the Nominating Committee shall notify the chairman and secretary of the executive committee of each geographical District, and the chairman and secretary of each technical division committee that, by December fifteenth of that year, each District and each technical division should select a representative to serve as a member of the AIEE Nominating Committee and an alternate to serve if the representative is unable to attend the meeting of the Nominating Committee. The names of representatives and alternates, so selected, should be transmitted by the above designated officers to the secretary of the Nominating Committee by December fifteenth.

During September of each year, the secretary of the Nominating Committee shall notify the chairman and secretary of the executive committee of each geographical District in which there is, or will be during the year, a vacancy in the office of Vice-President that, by December fifteenth of that year, a nomination for a Vice-President in that District made by the District executive committee should be in the hands of the secretary of the Nominating Committee.

Between October first and December fifteenth of each year, the Board of Directors shall choose a number of its members, not exceeding the number of technical divisions, to serve on the Nominating Committee, and notify the secretary of the Nominating Committee of the names of the members so chosen.

In the fourth paragraph of Sec. 23, delete the word "fifteen" at the end of the first line of this paragraph. This change is necessary because of the increase in size of the committee as result of the new constitutional amendment.

The Board approved the recommendation of the Edison Medal Committee that arrangements be made with counsel for AIEE and The New York Trust Company, as Trustee under the trust indenture dated March 26, 1908, that the corpus of said trust (known as Edison Medal Fund) be transferred by judicial settlement to AIEE, and that AIEE be appointed as successor or substituted trustee in the place and stead of said The New York Trust Company who shall resign; and if feasible, to consolidate the corpus of said trust fund with the fund recently established in the AIEE to provide additional income for the purpose of making the annual medal award.

Upon recommendation of the Headquarters Committee, the Board authorized the Secretary to:

1. Limit the stock of back issues of *Electrical Engineering* to a period of 5 years.

2. Discard preprints of *Transactions* papers after 2 years.

3. Discard Special Technical Publications and Technical Conference Reports when the demand has dropped to a point where the volume of indicated future sales in the Secretary's judgment, warrants.

4. Discard all stocks of Standards when superseded, except one file copy.

5. Discard routine correspondence files after 3 years.

6. Discard Section, Branch, and committee records after 5 years.

7. Prepare a form by which requests for publications not in stock can conveniently be answered with information as to the location of the desired material in the permanent printed records of the AIEE and the method and cost of obtaining it.

The Board voted to elect Julius C. Strasbourger of Cleveland, Ohio, to the unexpired term of Director ending July 31, 1954, succeeding President Elgin B. Robertson.

Upon recommendation of the Sections Committee, the Board voted that the New Hampshire Section, formerly the New Hampshire Subsection of the Boston Section, be admitted to the Institute as the 100th Section.

Upon a request from Creative Frontiers, Inc., for certain limited endorsement and co-operation, which request was referred to the Committee on Public Relations by the Board of Directors for consideration and such action as it deems appropriate, the committee reported that it would be willing to undertake to provide a responsible reviewer for scripts submitted, for which the Institute would act as host, obtaining where necessary competent technical advice. The Institute, however, should insist that:

1. They (the Institute) should have final say on the material included in the script.

2. The Institute will not assume the responsibility for the initial selection of individuals to be "glorified" on the program.

3. They are to be advised of the other scripts, individuals, and organizations that participate in the over-all program. This matter is directed toward keeping the Institute free from being associated with controversial sociological subjects which would not be compatible with the objectives of the Institute.

4. The Institute is, in no way, to be committed to any financial contribution.

The Executive Committee of the Engineers' Council for Professional Development (ECPD) recommended to the AIEE the appointment of the following Institute members as members of the indicated committees of ECPD:

Education: H. L. Hazen, W. L. Everitt
Student Development: Lee H. Hill, Eugene W. O'Brien
Training: Donald Bridgman
Recognition: George H. O'Sullivan
Ethics: R. W. Sorensen
Information: C. S. Rich

The Board voted to approve the appointment of the foregoing list and further to delegate to the AIEE representative on the ECPD Executive Committee, Morris D. Hooven, the authority to complete the list of required appointments to ECPD committees.

The Board voted to approve the proposal received from University Microfilms, Inc., endorsed by the UET Library Board, and approved by the AIEE Publication Committee, calling for permission to be granted for the microfilming of 12 issues of *Electrical Engineering* for which privilege University Microfilms, Inc., will pay AIEE 10 per cent of all gross sales of microfilm from *Electrical Engineering*, in addition to which AIEE will be furnished with one complete set of such films.

A letter was presented from the chairman of the Liaison Committee of the Institute of Electrical Engineers of Japan, requesting that the AIEE designate Dr. W. W. Lewis, Emeritus Professor of Union College, as the official lecturer representing the Institute before the Institute of Electrical Engineers of Japan. The Board voted to approve the request.

An invitation was received from the American Institute of Consulting Engineers for the Institute to be represented at their Annual Dinner in New York on October 19, 1953, at which time an award of merit is to be made, and on which occasion the representative of AIEE is to be a special guest.

The AMIME (Mexican National Engineering Organization) extended an invitation to delegates from AIEE to attend its Third National Congress, November 29–December 3, 1953. The appointment of a suitable delegation was left to the president.

The president was authorized to appoint delegates to attend the 35th Anniversary of the American Standards Association to be held in New York on October 19, 1953.

The Board voted to refer the invitation from the National Research Council for the AIEE to be represented at a conference to be held October 22–23, 1953, in New York, on the subject of training in the field of applied mathematics, to the chairman of the Subcommittee on Applied Mathematics of the Committee on Basic Sciences.

ATTENDANCE

Present at the meeting were: *President* Elgin B. Robertson; *Past President* F. O. McMillan; *Vice-Presidents* C. P. Almon, Jr., A. S. Anderson, W. L. Cassell, G. D. Floyd, W. Scott Hill, M. D. Hooven, Thomas Ingledow, C. M. Lytle, Walter B. Morton, George C. Tenney; *Directors* Donald I. Cone, R. F. Danner, D. D. Ewing, L. F. Hickernell, T. M. Linville, N. C. Pearcy, C. S. Purnell, E. W. Seeger; *Treasurer* Walter J. Barrett; *Secretary* H. H. Henline, and *Assistant Secretary* N. S. Hibshman.

355 Attend Conference on Air-Moving Equipment

General Chairman J. H. Capps has just presented Dr. E. E. Voekel, Minister, Plymouth Congregational Church, as guest speaker at the luncheon held during the Conference on the Application of Motors to Air-Moving Equipment. Dr. Voekel spoke on "Humor in the Ministry"

The AIEE Conference on the Application of Motors to Air-Moving Equipment and Symposium on Induction Motors, held in the Van Orman Hotel in Fort Wayne, Ind., October 6–8, drew a total registration of 355. This is the second conference on small motors and their application to a special line of products. The first was held in Dayton, Ohio, in October of 1951 and dealt with the application of motors to pumps.

Sponsored by the Committee on Rotating Machinery and the Fort Wayne Section, the conference was opened with words of welcome by M. L. Miller, Section chairman.

All of the papers were very well received, and were followed by periods of discussion. J. E. Noest, Commonwealth Edison Company, New York, N. Y., expressed the utilities' concern over the huge load represented by room air conditioners. In the event of a power outage, this load would be waiting to come on when power was restored. This terrific starting demand might make it impossible to restore service. He suggested some provision be made to cascade the starting of the unit's motors. Other discussions centered around the shaded-pole motor, its advantages and limitations for room air-conditioning application, and the present 15-ampere limit set on these units. Questionnaires passed out at the last session indicated a desire for similar conferences to be held in the future.

The symposium on the induction motors offered a variety of papers covering motor analysis and design problems. Papers were presented to a very interested group which offered numerous points for discussion.

The following were chairmen of the various conference committees: J. H. Capps, general chairman; P. O. Noble, program chairman; Sol London, arrangements; J. A. Walley, reservations and registrations; M. J. Carroccio, publicity; R. E. Trovinger, student participation; D. D. Hershberger, conference treasurer.

AIEE Will Be Joint Sponsor of Conference on Transistor Circuits

A Conference on Transistor Circuits will be sponsored jointly by the Institute of Radio Engineers Professional Group on Circuit Theory and subcommittees of the AIEE Committee on Electronics on February 18–19, 1954, in Philadelphia, Pa.

The conference will include papers discussing the representation of transistors for circuit design purposes, problems peculiar to the design of transistor circuits, and current trends in transistor circuit designs in both linear and pulse applications. The conference is designed to appeal primarily to engineers working actively with transistor circuits; consequently, introductory concepts of transistor circuit design and performance will not be reviewed in any detail.

Registration material will be ready for mailing early in January, and details of the registration procedure will be announced at that time.

Head Named President in Recent UET Elections

James L. Head of the Anaconda Copper Mining Company has been elected president of United Engineering Trustees, Inc., (UET) succeeding R. F. Gagg, president for the last 2 years. Mr. Head has been active in the work of the American Institute of Mining and Metallurgical Engineers whom he has represented on the Board of UET since 1947. He was chairman of the Engineering Societies Library for the past 2 years, and vice-president of UET, and is a past president of the Mining and Metallurgical Society of America.

Other officers named at the recent elections were Gail F. Moulton, Rockefeller Brothers, Inc., and AIEE Treasurer Walter J. Barrett (F '50), New Jersey Bell Telephone Company, vice-presidents; Waldo G. Bowman, McGraw-Hill Publishing Company, treasurer; and Joseph L. Kopf, Jabez Burns and Sons, Inc., assistant treasurer. John H. R. Arms was re-elected as secretary and general manager, a position he has occupied since 1933. Mr. Moulton was elected chairman of the finance committee and Mr. Gagg, chairman of the real estate committee.

UET was incorporated in 1904 by corporators appointed by the civil, mining, mechanical, and electrical engineering societies for "the advancement of the engineering arts and sciences in all their branches and to maintain a free public engineering library." Its members, three appointed by each Founder Society, are empowered to act for the societies in all matters of common interest.

Villanova Student Branch Reports Recent Activities

The Joint AIEE–Institute of Radio Engineers (IRE) Student Branch at Villanova College, Villanova, Pa., reports a number of activities held during the month of October. Joseph Zator is the Branch chairman.

At the meeting on October 8, Father Klekotka, Student Branch IRE counselor, discussed the benefits of the IRE. The advantages of AIEE membership were discussed by J. B. Clothier, the Branch moderator.

F. Hershey, a representative from the AIEE Student Action Committee in Philadelphia, Pa., spoke at the second business meeting on October 15. The purpose of his talk was to point out the advantages of AIEE membership to the students and to encourage all those who had not joined to do so.

On October 19, members of the Villanova Branch went on their first field trip of the current school year, to the Southwark Power Plant of the Philadelphia Electric Company. The tour covered all phases of the preparation of the fuel, the operation of the boilers, the turbines, the generators, the condensing units, and circuit breaking equipment.

Present at the first formal smoker of the Branch on October 20 were two engineers from the Philadelphia Electric Company who discussed work of their respective departments.

The first speaker, Marshal Adams, explained the working of the transmission and distribution department, emphasizing the advance planning that is necessary in distribution work. Mr. Clouse, the second speaker, is affiliated with the company's Bulk-Power Transmission System. His talk included the future sites of power stations, the general layout of present power stations, and the interconnections of the Philadelphia Electric Company with neighboring utilities.

Fourth Annual Awards Made Under Section Growth Plan

At the Section Delegates Conference held during the AIEE Summer General Meeting at Atlantic City, N. J., in June, awards were made for the fourth time under the Section Growth Award Plan.

First prizes of a gavel, suitably inscribed, were awarded to the Schenectady Section and the Spokane Section for the larger-than-average Sections and the smaller-than-average Sections, respectively, for the year 1952–53.

Second prizes of a certificate, suitably engraved, were awarded to the Maryland Section and the Cincinnati Section for the larger-than-average Sections and the smaller-than-average Sections, respectively, for the year 1952–53.

So that all eligible Sections might evaluate their relative performance, Table I has grouped the Sections by Districts and shows the effect of membership and attendance growth in each case.

To date, the plan has been administered without any fundamental change being made in the original Growth Plan formula.

Basing Section performance on membership and attendance still appears to be the best criteria and, also, provides a workable plan which is easy to apply. It continues to be the opinion that all other accomplishments of a Section eventually have their effect on either membership or attendance, or both.

Under the rules governing the Section Growth Award, any Section may be disqualified by the judging committee if it finds anything in the Section's particular record so abnormal as to give it an unfair advantage over the other Sections. For the last three awards, several instances have been noted of a meeting attendance that exceeds the Section membership to such a degree that it has a marked effect on the Growth Factor. Since this was not an isolated case and it is desirable to avoid disqualification wherever possible, the judging committee has limited the credit for attendance per meeting to a maximum of 250 per cent of the Section membership. The amount of this limitation was not arbitrarily selected; on the contrary, it is the result of an extensive graphical analysis which showed it to be the best to accomplish the intention which is to eliminate the effect of meetings with unusually large attendance.

The administration of the Section Growth Award Plan is the responsibility of the Sections Committee and awards for each year are made at the conference held for Section Delegates during the Summer General Meeting. More detailed explanation of the Sections Growth Award Plan is available in the September 1951 issue, pages 820–2.

Table I. Growth Factors for the Year 1952–53 of All Eligible Sections Arranged by Districts

	Size of Section (See Note 1)	Per Cent Increase in Membership	Per Cent Increase in Attendance × 1/3	Growth Factor
District 1				
Boston	L	4.3	− 0.2	4.1
Connecticut	L	9.5	− 5.3	4.2
Ithaca	S	16.9	− 5.7	11.2
Lynn	S	14.2	8.0	22.2
Niagara Frontier	S	− 2.3	−17.2	−19.5
Pittsfield	S	4.9	13.2	18.1
Providence	S	− 1.2	7.0	5.8
Rochester	S	− 0.8	−10.6	−11.4
Schenectady	L	5.2	31.9	37.1
Springfield, Mass.	S	0	− 5.9	− 5.9
Syracuse	S	15.9	18.3	34.2
Worcester	S	− 0.9	20.2	19.3
District 2				
Akron	S	1.6	−28.7	−27.1
Canton	S	9.6	− 6.0	3.6
Cincinnati	S	25.0	17.7	42.7
Cleveland	L	7.6	3.7	11.3
Columbus	S	11.8	10.3	22.1
Dayton	S	7.0	−16.9	− 9.9
Delaware Bay				
Erie	S	12.7	2.8	15.5
Lehigh Valley	S	6.4	5.1	11.5
Mansfield	S	− 1.0	17.8	16.8
Maryland	L	15.0	12.8	27.8
Ohio Valley				
Philadelphia	L	14.2	5.4	19.6
Pittsburgh	L	2.5	2.1	4.6
Ridgeway				
Sharon	S	12.0	− 4.6	7.4
Toledo	S	13.0	13.8	27.1
Washington	L	2.7	− 9.9	− 7.2
West Virginia	S	4.2	4.5	8.7
District 3				
New York	L	5.9	− 7.7	− 1.8
District 4				
Alabama	S	17.8	− 0.7	17.1
East Tennessee	S	4.7	22.1	26.8
Georgia	S	10.7	− 2.4	8.3
Jacksonville	S	− 1.3	7.2	5.9
Louisville	S	25.8	− 4.3	21.5
Memphis	S	6.4	3.2	9.6
Miami	S	11.9	3.1	15.0
Mississippi				
Mobile-Pensacola				
Nashville				
New Orleans	S	− 0.7	− 2.3	− 3.0
North Carolina	S	1.5	−15.2	−13.7
Oak Ridge				
South Carolina	S	12.1	− 8.5	3.6
Tampa				
Virginia	S	3.5	− 3.7	− 0.2
Virginia Mountain	S	8.9	25.4	34.3
District 5				
Arrowhead	S	5.2	7.6	12.8
Central Illinois	S	− 4.9	−11.8	−16.7
Central Indiana	S	4.9	− 8.7	− 3.8
Chicago	L	3.1	− 0.9	2.2
Fort Wayne	S	3.9	13.4	17.3
Illinois Valley	S	3.3	−11.2	− 7.9
Iowa	S	2.5	6.7	9.2
Madison	S	4.0	0.9	4.9
Michigan	L	12.0	− 1.1	10.9
Milwaukee	L	10.9	0	10.9
Minnesota	S	5.2	− 6.8	− 1.6
Northeast Michigan				
Rock River Valley	S	12.6	− 3.1	9.5
South Bend	S	8.0	0.7	8.7
District 6				
Denver	L	2.5	0.8	3.3
Nebraska	S	8.7	−10.7	− 2.0
District 7				
Arkansas	S	14.3	2.0	16.3
Beaumont	S	9.2	4.9	14.1
Corpus Christi				
El Paso	S	12.1	20.8	32.9
Houston	S	12.5	− 4.4	8.1
Kansas City	S	11.4	− 1.3	10.1
Mexico	S	2.0	− 8.6	− 6.6
North Texas	L	8.7	13.2	21.9
Northern New Mexico	S			
Oklahoma City	S	2.7	13.3	16.0
Panhandle Plains	S	3.4	1.2	4.6
St. Louis	L	11.8	− 6.9	4.9
Shreveport	S	16.0	10.9	26.9
South Texas	S	− 4.7	− 4.0	− 8.7
Tulsa	S	16.6	12.5	29.1
Wichita	S	10.2	23.0	33.2
District 8				
Arizona	S	1.4	−11.7	−10.3
Los Angeles	L	15.9	− 0.4	15.5
Sacramento				
San Diego	S	15.4	− 9.8	5.6
San Francisco	L	12.1	− 8.9	3.2
District 9				
Montana	S	0.8	− 6.6	− 5.8
Portland	L	1.7	5.8	7.5
Richland	S	7.1	0.4	7.5
Seattle	L	13.2	1.4	14.6
Spokane	S	0	51.1	51.1
Utah	S	11.0	− 6.5	4.5
Vancouver	S	9.9	2.6	12.5
District 10				
Montreal	S	18.3	19.4	37.7
Niagara Int'l.	S	10.8	15.8	26.6
Ottawa	S	8.8	− 6.0	2.8
Toronto	L	13.4	− 4.8	8.6

Note 1

S—Sections which have a membership equal to, or less than, the average eligible Section.
L—Sections which have a membership greater than the average eligible Section.
Those Sections not designated are ineligible because they were less than 4 years old on May 1, 1953.

Missouri Mines Branch Opens New School Year

The Joint AIEE–Institute of Radio Engineers Student Branch at the Missouri School of Mines, Rolla., Mo., opened the month of September and the 1953–54 school year with more than 350 students attending the first two meetings. Branch chairman is Fred Burns and the faculty advisor, J. W. Rittenhouse.

More than 230 students attended a demonstration of "Microwaves and Your Telephone" given by the Bell Telephone Company. Some 120 freshmen who attended the freshman smoker toured the electrical engineering department and were told of the merits and purposes of the AIEE. More than 30 per cent of the students joined the Student Branch and 13 per cent signed up for membership in the national organization. At the present time more than 65 per cent of the students in the electrical department belong to the student organization.

Plans are now in preparation for an inspection trip to the Frisco Railroad's Diesel Shops, together with a visit to the campus by R. F. Danner, AIEE Director and chairman of the Committee on Student Branches.

President and Secretary Attend EUSEC Meeting in Paris

As authorized by the Board of Directors on April 23, 1953, President Robertson and Secretary Henline attended a meeting of the Conference of Representatives from the Engineering Societies of Western Europe and the United States of America (EUSEC) held in Paris, France, September 7–11, 1953.

Among the topics considered were definitions of the terms "professional engineer" and "engineering technician," international conferences on engineering education, exchanges of publications and lecturers, visits of students, abstracting services in the engineering field, relations with other international engineering organizations, EUSEC *Bulletin*, the possibility of developing an international code of ethics for engineers, and admission of other engineering societies to EUSEC.

Thursday, September 10, was devoted to an all-day trip through the wine-growing country of France and visits in Reims and vicinity.

Friday was devoted to the presentation of various reports and the adoption of recommendations and resolutions. The last event was a banquet Friday evening.

After the meeting, Messrs. Robertson and Henline spent a brief vacation traveling through Switzerland and Italy.

Susquehanna and New Hampshire Become Sections 99 and 100

With the installation of the New Hampshire Section in Manchester, N. H., on October 8, 1953, the AIEE marks the organization of its 100th Section. Just one day previously, on October 7 in Lancaster, Pa., the Susquehanna Section was officially recognized as the 99th Section.

At the Susquehanna Section Charter Night banquet are (left to right): Paul Kaseman, Section secretary; C. J. Backstrand, Armstrong Cork Company; Bartow Van Ness, Pennsylvania Water and Power Company; Miles Keiffel, banquet chairman; Dr. H. H. Beck, speaker; K. J. Granbois, Section chairman; Vice-President W. B. Morton; G. T. Storb, Pennsylvania Power and Light Company; G. E. Conn, past chairman Lancaster-York Subsection; H. W. Becker, Rector, St. Johns Episcopal Church

Vice-President W. Scott Hill presents the New Hampshire Section charter to G. F. Austin, chairman of the former Subsection. Looking on are Directors C. S. Purnell (left) and Victor Siegfried and Assistant Secretary N. S. Hibshman

W. Scott Hill, Vice-President of the North Eastern District, presented the charter to the new New Hampshire Section. In his address he pointed out that "100" is a symbol of value, whether it be in age, distance, or speed, or, as in this case, as an indication of growth.

Also present at the inaugural meeting in New Hampshire was N. S. Hibshman, Assistant Secretary for the Institute, and Directors Victor Siegfried and C. S. Purnell.

The newly organized Susquehanna Section was officially recognized at a Charter Night banquet at which W. B. Morton, Vice-President, Middle Eastern District, presented a charter and gave a short talk on "This Is Your Institute." The main speaker was Dr. H. H. Beck, professor emeritus of chemistry and mineralogy and director of the North Museum of Franklin and Marshall College, who traced life in the Susquehanna Valley back to 12,000 years before Christ in his talk, "The Old Susquehanna."

The new Susquehanna Section is comprised of members formerly affiliated with the Lancaster-York Subsection of the Maryland Section.

District 7 Adopts Student Branch Manual

Early this fall there were distributed to every Student Branch in District 7 two copies of the first Student Branch Manual ever to be used in that District.

This manual, which consists of a complete compilation of suggestions, bylaws, and constitutional provisions relating to the conduct of Student Branch affairs, represents the culmination of many years of planning by the Branch counselors of the District. After discussing the potential contents of such a manual for more than 3 years, the District Committee on Student Activities appointed a subcommittee in April of 1952 to prepare a rough draft of such a manual for discussion at the counselors' meeting in 1953.

Working under the supervision of this subcommittee, composed of Professors Joseph W. Rittenhouse of Missouri School of Mines and J. Bruce Wiley of The University of Oklahoma, three Student members of the Missouri School of Mines Branch, George McCormick, Eugene Ellis, and Richard Reeg, compiled the rough draft of the manual which was adopted at the April 1953 meeting of District 7 Student Activities Committee.

The money derived from contributions from the Sections and Student Branches in the District made possible the preparation of 200 copies of the manual, most of which will be distributed for criticism to people throughout the Institute during the coming year. It is hoped that the criticisms obtained in this manner will result in a much improved manual for the 1954–55 academic year.

The contents of the manual are taken from many sources, but probably the largest single source is the regular set of mimeographed information letters which national headquarters annually sends to all Student Branches. In its final form it consists of 48 pages bound in loose-leaf form in press-board covers. The loose-leaf arrangement will permit ready revision simply by the replacement of individual pages as they become obsolete.

Of particular value are the 17 appendixes which contain samples of the various forms such as meeting minutes forms, financial statement forms, and membership application forms, and also contain a complete copy of the national Constitution and Bylaws as well as a place to insert the local Branch constitution.

It is expected that the introduction of this manual greatly will facilitate the smooth functioning of Student Branches in the South West District. This year will mark the first time that a new set of Branch officers or a new counselor will have at the beginning of their terms of office a complete set of instructions bound into a single book to answer the many questions that always arise at the beginning of a new year of student activities.

Machine Tool Conference Is Held in Cleveland, Ohio

The sixth annual AIEE Conference on Machine Tools, sponsored by the AIEE Subcommittee on Machine Tools, was held at the Cleveland Hotel, Cleveland, Ohio, October 14–16, 1953. The AIEE Cleveland Section acted as host to this conference and took care of all local arrangements including plant tours, banquet, and so on. The 584 persons attending the conference represented mainly electrical and mechanical engineers with machine-tool builders, electrical manufacturers, and large users of machine tools, such as the automotive and aircraft industries.

Technical papers were presented on a wide variety of subjects including electron drives, automatic control, electrical codes in the machine tool industry, clutches, and dynamic brake motors.

The technical program provided the engineers with up-to-date information on new products, processes, and techniques. They had an opportunity to discuss their applications and mutual problems in connection with various standards, codes, and safety regulations applicable to the designing, building, and use of electrified machines. In this connection one of the subjects was "Today's Machine Tools Need Modern Electrical Codes."

Plant tours were scheduled of the Ford Motor Company, Engine Plant; Warner-Swasey Company; Reliance Electric and Engineering Company; Chevrolet Motor Company, Transmission Plant.

Tell Berna, toastmaster at the banquet on October 14, introduced Frederick S. Blackall, Jr., the principal speaker. Mr. Blackall is president of Taft-Pierce Manufacturing Company and president of The American Society of Mechanical Engineers. In his address on "The Engineer's Obligation to a Free Society," he challenged the engineer to be alert to social problems. He cited the conference as an example of how engineers of different professions and societies could co-operate in undertaking subjects and problems of common interest.

Shown at the Machine Tool Conference banquet are (left to right): AIEE Director J. C. Strasbourger; R. H. Clark, general chairman of the Subcommittee on Machine Tools; F. S. Blackall, Jr., president, ASME; Tell Berna, toastmaster; H. B. Osborn, Jr., national second vice-president, American Society of Tool Engineers

Annual AIEE Prizes Listed in Various Classifications

The following is a reminder of the awards which are available each year in each classification:

1. *Institute*

Class	First Prize	Second Prize
(*a*). Power	$100 and certificate	Certificate
(*b*). Industry	$100 and certificate	Certificate
(*c*). Communication	$100 and certificate	Certificate
(*d*). General Applications	$100 and certificate	Certificate
(*e*). Science and Electronics	$100 and certificate	Certificate
(*f*). Best Student Paper	$100 and certificate	Certificate

2. *District*

Class	First Prize	Second Prize
(*a*). Best paper, any class	$75 and certificate	$50 and certificate
(*b*). Best paper presented by undergraduate Student member in District competition	$25 and certificate	Certificate

3. *Section*

$100 to be divided at the discretion of the Section with a maximum of $50 for any one prize and certificate for each winner.

4. *Branch (Undergraduate)*

Class	First Prize	Second Prize
(*a*). Best Paper	$10 and certificate plus an allowance of 13 cents per mile one way for 800 miles or less and 10 cents per mile one way for remaining distance to the District Student prize paper competition	Certificate

Coauthors will split prize; each will receive a certificate. Equivalent gift may be substituted for the monetary prize.

The complete rules for the award of prizes for AIEE technical papers appear in the September 1952 issue of *Electrical Engineering* (page 815).

Program Announced for Joint Computer Conference

"Information Processing Systems—Reliability and Requirements," is the general theme of the Eastern Joint Computer Conference and Exhibition sponsored by the Institute of Radio Engineers, the Association for Computing Machinery, and the AIEE, to be held December 8–10, 1953, at the Statler Hotel, Washington, D. C.

Mark Swanson, chairman of the local committee on arrangements, has announced the completion of plans for all important aspects of this conference. L. R. Johnson, vice-chairman in charge of registration, stated that present interest in the conference indicates an attendance of at least 1,600 persons. The reception and cocktail party already planned by Stanley F. Reed assures the opportunity for a thorough get-together with all speakers and other participants of the conference.

Dr. Howard T. Engstrom, chairman of the technical program committee, reports that arrangements have been made final for the following presentations:

Tuesday, December 8

Morning

"Address of Welcome," John H. Howard, Burroughs Corporation

"Keynote Address," Howard T. Engstrom, Remington Rand, Inc.

The RTMA Support of the 1950 Computer Conference—A Progress Report. *Thomas H. Briggs*, Burroughs Corporation

The Use of Electronic Data Processing Systems in the Life Insurance Business. *M. E. Davis*, Metropolitan Life Insurance Company

Computer Applications in Air Traffic Control. *Vernon I. Weihe*, Air Transport Association of America

Afternoon

Data Processing Requirements for the Purposes of Numerical Weather Prediction. *Joseph Smagorinsky*, United States Weather Bureau

Methods Used to Improve Reliability in Military Electronics Equipment. *L. D. Whitelock*, Bureau of Ships

Digital Computers for Linear, Real-Time Control Systems. *Ralph B. Conn*, Jet Propeller Laboratory, California Institute of Technology

Wednesday, December 9

Morning

Reliability Experience on the OARAC. *Robert W. House*, Wright-Patterson Air Force Base

Operating Experience With the Los Alamos 701. *Willard G. Bouricius*, Los Alamos Scientific Laboratory

Acceptance Tests for the Raytheon Hurricane Computer. *Professor Francis J. Murray*, Columbia University

Reliability of a Large REAC Installation. *Bernard D. Loveman*, Reeves Instrument Corporation

National Bureau of Standards Performance Tests. *S. N. Alexander, R. D. Elbourn*, National Bureau of Standards

Experience on the Air Force UNIVAC. *Robert Kopp*, Headquarters, United States Air Force

Afternoon

Electron Tube and Crystal Diode Experience in Computing Equipment. *J. A. Goetz, H. J. Geisler*, International Business Machines Corporation

Reliability and Performance of the ILLIAC Electrostatic Memory. *Joseph M. Wier*, University of Illinois

Electron Tube Performance in Some Typical Military Environments. *D. W. Sharp*, Aeronautical Radio Inc.

Thursday, December 10

Morning

SEAC—Review of 3 Years of Operation. *R. A. Kirsch, P. D. Shupe, Jr.*, National Bureau of Standards

A Review of ORDVAC Operating Experience. *Charles R. Williams*, Ballistic Research Laboratory

Some Remarks on Logical Design and Programming Checks. *Herman H. Goldstine*, The Institute for Advanced Study

The Advantages of Built-in Checking. *John W. Mauchly*, Remington Rand, Inc.

Recent Progress in the Production of Error-Free Magnetic Computer Tape. *W. W. Wetzel*, Minnesota Mining and Manufacturing Company

Afternoon

Reliability of Electrolytic Capacitors in Computers. *Mark VanBuskirk*, P. R. Mallory and Company, Inc.

A Method of Reliability Specification and Its Application to Transistors. *W. J. Pientenpol*, Bell Telephone Laboratories

Case Histories in Resistor Reliability. *Jesse Marsten*, International Resistance Company

The MIT Magnetic-Core Memory. *William N. Papian*, Massachusetts Institute of Technology

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Discussion of these papers will occur both in the sessions themselves and in additional sessions to be held solely for the purpose of discussing topics of unusual interest. Miss Margaret Fox, vice-chairman for inspection trips, has completed arrangements for visits to various computer installations in the Washington area. All registrants will have the opportunity to indicate which inspection trips they prefer to make.

L. D. Whitelock, vice-chairman for exhibits, has prepared an unusual arrangement for demonstrators at the Statler Hotel. A unique feature of this arrangement provides a large uncongested area so that all parties will be able to view exhibits specially arranged by outstanding manufacturers. Several of the latest developed components will make their initial appearance at this Joint Computer Conference.

Preliminary announcements have been mailed to all members of the sponsoring organizations. The final program and applications for reservations now are being processed for the same mailing list. Interested parties who are not members of any one of the three sponsoring organizations may request the final program and reservation application from L. R. Johnson, 2018 Sycamore Drive, Falls Church, Va.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

General Applications Division

Committee on Domestic and Commercial Applications (*T. C. Johnson, Chairman; H. F. Hoebel, Vice-Chairman; J. H. T. Miller, Secretary*). Developments in heat pumps and electric space heating, domestic appliances, and farm electrification all will be the subjects of technical sessions at General meetings or at special technical conferences sponsored by the respective subcommittees during the coming year.

The steadily increasing interest in heat pumps and the related uses of electricity for the home will be covered by technical sessions at the 1953 Winter General Meeting in New York, N. Y., and the 1954 Summer and Pacific General Meeting in Los Angeles, Calif. The scope of this field, which also includes the rapidly growing business of domestic air conditioning, is such that subcommittees have been organized to operate actively on both the East and West Coasts.

The fifth Appliances Technical Conference will be held in Chicago, Ill., May 17–19, 1954, carrying on the very successful conferences of previous years. This series of conferences has covered a large range of subjects on appliance design, development, and application which are of value to many people who are not normally involved in the other aspects of the engineering field.

As developments in farm electrification have been making progress also, a special technical conference is being planned to consider the situation. As this will be the first such conference sponsored solely by AIEE (the last conference was held jointly with the National Farm Electrification Conference, now discontinued) suggestions and encouragement from AIEE members will be welcome.

Industry Division

Committee on Industrial Power Systems (*S. A. Warner, Chairman; R. H. Whaley, Vice-Chairman; R. T. Woodruff, Secretary*). This committee now is starting its consideration of needs and possibilities of sessions for the General meetings 1 year in advance of the meetings. One member of the committee accepts the responsibility of sponsorship of a session and, with the help of other members geographically situated to the meeting location, develops the session in all its detail. The session at the Kansas City meeting thus was sponsored and developed by D. M. Allison of Tulsa, Okla. The session for the Winter General Meeting on grounding in industrial plants, associated with active subcommittee work on this subject, is being developed by D. L. Beeman of Schenectady, N. Y. A session for the Summer and Pacific General Meeting in Los Angeles, Calif., is being developed by F. M. Dorey of Los Angeles, with the assistance of other committee members in the North West and Pacific Districts.

One of the most important activities of the subcommittees is the revision of the Red Book, officially known as the "Special Publication—Electric Power Distribution for Industrial Plants." The Red Book was published about 10 years ago and approximately 20,000 copies were sold. Developments since its publication require that much of the information be revised and expanded. During the past year, under the subcommittee chairmanship of R. R. Nissley of New York, N. Y., working groups were established for each of the 11 chapters to comprise the proposed new publication. Every effort is being made to have the material ready for printing before the end of this administrative year.

Committee on Industrial Control (*H. L. Palmer, Chairman; L. H. Matthias, Vice-Chairman; J. W. Picking, Secretary*). The Committee on Industrial Control has been organized with 39 members, with the following subcommittees.

The *Subcommittee on Test Codes* has finished a proposal which now is being studied by the membership of the main committee. This code is divided into five sections:

1. Procedures for Conducting Continuous- and 8-Hour-Duty Temperature-Rise Tests on A-C and D-C Controllers.
2. Procedures for Conducting Temperature-Rise Tests on Resistors, Rheostats, and Their Assemblies.
3. Test Procedures for A-C and D-C Magnetic Contactors.
4. Test Procedures for A-C Magnetic Controllers.
5. Test Procedures for D-C Magnetic Controllers.

At the completion of this review, these test codes will be published and made available for general use.

The *Subcommittee on Standards* has finished a review and revision of "Definitions of Electrical Terms" covered by ASA Standard *C42*. Considerable work has been done on a review and revision of the graphical symbols and this project is practically complete. The next assignment of this subcommittee is to study AIEE Standard Number *15* on control apparatus and work will start on this project during the next year.

The *Subcommittee on Bibliography* has finished a very complete bibliography on control subjects. Their latest contribution is Part 3 on feedback control, which was prepared jointly with a similar subcommittee of the Committee on Feedback Control Systems. These bibliographies have been published and can be obtained from AIEE Headquarters.

The *Subcommittee on Electronic Control* has been divided into working groups covering various phases of this very broad subject. Their efforts have been directed towards preparation of definitions and terminology. Some of the efforts of this subcommittee have been included in the latest revision of ASA Standard *C42* on definitions; however, there is still much work to be done.

The *Subcommittee on Feedback Controls* has been serving as a liaison between the Committee on Industrial Control and the Committee on Feedback Control Systems. Their work at the present time has been limited to the co-ordination of the preparation of terms and definitions used in feedback control systems.

A *Subcommittee on Prize Paper Awards* has been established also.

The scope of the Committee on Industrial Control covers a very active and rapidly changing phase of American industry. There is a wealth of material to be covered by technical papers in this field. The principal participants in this activity at the present time are the manufacturers of control equipment. Much more could be accomplished in this committee if it could obtain greater participation by the users of the equipment. The committee thus will exert considerable effort during the next 2 years to try to encourage user participation on committees and in the technical sessions.

Power Division

Committee on Carrier Current (*S. C. Leyland, Chairman; L. G. Eaton, Vice-Chairman, East; L. E. Ludekens, Vice-Chairman, West; H. W. Lensner, Secretary*). A successful Symposium on Microwave and Carrier Current sponsored by the committee was held at the 1953 Pacific General Meeting in Vancouver, Canada. The all-day session was well attended, and much interest was shown in two committee reports which were presented. The morning session was on microwave, and the highlights of a report on "Installation and Operating Experience of Microwave for Power Systems" served as a basis for discussion. Particular interest was shown in the question of emergency power supplies for microwave installation.

The afternoon session started with a brief presentation of another report, "Application Guide for Power-Line Carrier," which was concerned primarily with channel characteristics and line-coupling practice rather than terminal equipment. The discussion which followed covered a variety of subjects, including coupling methods, use of line traps, line noise, and methods of measurement.

A full committee meeting was held recently in New York, N. Y., at which time plans for the 1954 Winter General Meeting were completed. The Carrier Current Committee also is planning to sponsor technical sessions at the 1954 Summer and Fall General Meetings.

Committee on Insulated Conductors (*M. H. McGrath, Chairman; M. W. Ghen, Vice-Chairman; L. E. Fogg, Secretary*). The organization of the Committee on Insulated Conductors has been completed for the administrative year 1953–54. There are 110 members and subcommittee members. In addition to the 12 subcommittees under which the activities of this committee have been carried on in the past, a new subcommittee, Number *13*, European Practice, has been formed under the chairmanship of L. I. Komives to cover new, novel, or unusual European development, practice, or experience on matters coming within the scope of the committee, and to promote the participation and co-operation of European engineers in the activities of the committee. The personnel of the new subcommittee includes representation from such countries as Denmark, France, Germany, Great Britain, Italy, Holland, Sweden, and Switzerland.

An AIEE Special Publication on insulated aluminum conductors, containing ten conference papers which were presented at the 1952 Fall General Meeting under the joint sponsorship of the Committees on Insulated Conductors and Industrial Power Systems, became available recently.

A 2-day meeting of the committee consisting of individual meetings of the various subcommittees on the first day and a general meeting of the entire committee on the second day were held in New York, N. Y., on November 17–18, 1953.

Committee on Switchgear (*R. L. Webb, Chairman; J. D. Wood, Vice-Chairman; J. M. Geiger, Secretary*). The Switchgear Committee held its first meeting of the present administrative year in Kansas City on October 31, 1953. The committee is organized this year with 55 members and 5 subcommittees.

The outstanding jobs being actively followed by the subcommittees are as follows:

Power Circuit Breaker Subcommittee

1. New basis for rating power circuit breakers. This work is nearing completion, and a report will be made to the Winter General Meeting of the Institute.
2. Study of single-phase interrupting ability of power circuit breakers.
3. Circuit breaker performance on line charging current interruption.
4. High-voltage circuit-breaker derating factors for reclosing duties.

Switchgear Assemblies Subcommittee

1. A report on the application and operation of outdoor metal-clad switchgear is approaching completion. It gives recommendations for operation to avoid excessive temperatures, due to solar heating. This report is expected to be ready for presentation at the Winter General Meeting.

Automatic Circuit Recloser Subcommittee

1. Preparation of AIEE Standard Number *50* for submission to American Standards Association.
2. Standards for line sectionalizers.

Low-Voltage Air Circuit Breaker Subcommittee

1. Preparation of a guide for the calculation of short-circuit currents in d-c systems.
2. Preparation of a Standard on molded-case air circuit breakers.

Switches, Fuses, and Insulator Subcommittee

1. Preparation of a guide for ice testing of disconnecting switches.
2. Preparation of a guide for the operation and maintenance of fuses and switches.
3. Preparation of a Standard for fuses, 600 volts and below.
4. Preparation of AIEE Standards Numbers *22* and *25* for submission to American Standards Association.

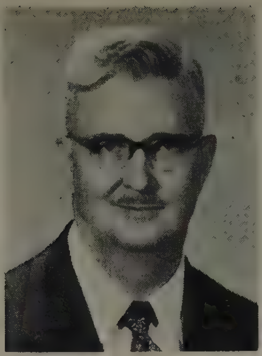
AIEE FELLOWS ELECTED . .

Board of Directors Meeting, September 3, 1953

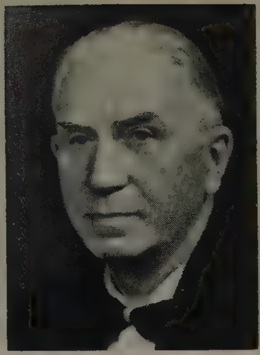
Edward F. W. Beck (M '35), section manager, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been transferred to the grade of Fellow in the AIEE "for outstanding contributions in the development of lightning arresters and in the science of protecting electric apparatus from damage by lightning voltage." Mr. Beck was born in New York, N. Y., May 24, 1895, and graduated from Columbia University in 1917 with a degree in electrical engineering. After a period with the Sperry Gyroscope Company, Brooklyn, N. Y.; General Electric Company, Schenectady, N. Y.; and Western Electric Company, New York, N. Y., he joined Westinghouse Electric Corporation, East Pittsburgh, Pa., in 1922 as a design engineer working on small rectifiers. In 1925 he began doing development and design work on lightning arresters for Westinghouse, becoming section manager, Lightning Arrester Engineering, responsible for research and development of equipment. From 1935 to 1937 he was chief engineer with Westinghouse X-Ray Company, Long Island City, N. Y. He returned to East Pittsburgh in 1938 as development engineer, lightning arresters, responsible for field research, design, and development of new distribution lightning arresters. Since 1941 he has been section manager, Lightning Arrester Engineering, responsible for research, development, design, and construction of lightning arresters, surge generators, and cathode-ray oscillographs. Mr. Beck has done much to im-

Edward F. W. Beck

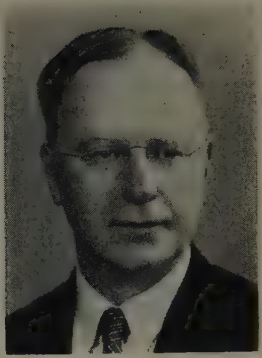
Clifford H. Cramer



Otis T. Farry



John D. Ferguson



Albert P. Godsho

prove the reliability of the distribution-type arrester and also has played an important part in the collection of field data on lightning currents and the current discharge by lightning arresters. He is continuing his activity in the arrester field by the development of new mechanical constructions of high-voltage arresters. Mr. Beck is a member of Sigma Xi and the Franklin Institute.

Clifford H. Cramer (AM '27, M '34), assistant transmission research engineer, The Western Union Telegraph Company, New York, N. Y., has been transferred to the grade of Fellow in the AIEE "for outstanding contributions to the ocean cable transmission arts and specifically for directing the development and design of electronic undersea repeaters." Mr. Cramer was born on August 24, 1895, in Cramer, Pa., and graduated from the University of Michigan in 1918 with a bachelor of science degree in electrical engineering. He joined Western Union that year as an engineering assistant. In 1921 he became research group leader responsible for development and design of disturbance mitigating devices, including land-line telegraphy and voice-frequency carrier; development and design of signal-shaping networks; duplexing equipment; and electronic terminal equipment for ocean cables. He was made assistant research engineer in 1934, being second-in-charge of a wide variety of research activities including the development of voice-frequency carrier telegraph systems; wire-line transposition systems; network development, and related coil and magnetic materials research; and studies of sun spot and earth potential phenomena. During this time, Mr. Cramer also supervised a specialized group of research and development workers engaged exclusively on ocean cable developments. He was appointed to his present position in 1940 and is second-in-charge of the direction of transmission research workers. Additional projects under his direction have included frequency modulation in telegraphy; high-frequency carrier development; multiplexing of microwave relay systems, including work on time-division multiplexing. Mr. Cramer has been responsible for the first application of undersea telegraph repeaters in transatlantic cables. He has served on the AIEE Committee on Communication (1947–48).

Otis T. Farry (AM '29, M '40), supervisor of power transformer engineering, Wagner Electric Corporation, St. Louis, Mo., has been transferred to the grade of Fellow in the AIEE "for original work in the development and design of power transformers, unit substations, and their accessories." Mr. Farry was born in Browning, Mo., August 11, 1901, and graduated from Central College in 1924. He started with Wagner Electric in 1925 as a student engineer in the Large Motor Engineering Department. In 1927 he became an engineer in the Distribution and Power Transformer Department. Since 1942 he has been supervisor of power transformer engineering. During this period he supervised the design of power transformers including oil-filled types 500 to 40,000 kva, noninflammable liquid-filled types 500 to 5,000 kva, and dry types 100 to 2,500 kva. The major part of his work has been concerned with the building of standard transformer equipment for the electrical industry and large users of electric power. He has developed testing equipment. One example is a circuit for 3-phase impedance and excitation tests that has advantages in accuracy of reading. From 1944 to 1951 he designed industrial substations which were factory assembled and tested, providing for easy installation in the field. These industrial substations generally included a high-voltage interrupter switch of 5- to 15-kv class, a transformer and low-voltage switchgear of 600-volt class, and suitable interlocks to prevent improper operation of the switches. Mr. Farry also has developed transpositions for transformer windings resulting in cost savings and reduced space requirements; space-saving arrangements for the application of cooling coils to power transformers; and winding temperature indicators and relays. Mr. Farry is a past chairman of the St. Louis Section of the AIEE.

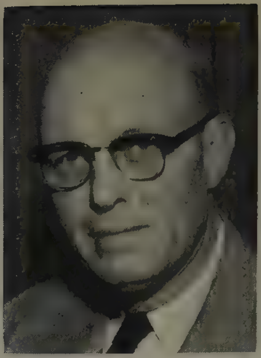
John D. Ferguson (M '24), managing director, MacEntee and Ferguson Ltd., Engineers, Dublin, Ireland, has been transferred to the grade of Fellow in the AIEE "for executive leadership and engineering contributions to the development of electric communication in the Republic of Ireland." Mr. Ferguson was born on May 26, 1891, in Belfast, Ireland, and received his bachelor of science degree in engineering from London University in 1920. He had previously had practical training as wireman, assistant electrician, and instrument mechanic in the Post Office Engineering Department, Belfast, becoming inspector in control of telephone exchanges and supervisor of the engineering staff in 1919. In 1921 he became chief inspector, Post Office Research Station, Dollis Hill, London, England, doing work on research of a general character. He joined the Department of Posts and Telegraphs, Dublin, in 1923 as assistant engineer, becoming assistant staff engineer, Power and Wireless Section, in 1925. He had full responsibility for design of lighting and heating installations, elevators, letter conveyors, telegram conveyors, electric clock, and time-signalling equipment. In 1930 he became staff engineer in charge of the power section. His responsibility included in addition to previous duties, co-ordination of power and communication circuits; preparation of specifications for Post Office engineering stores and apparatus; testing and acceptance of engineering apparatus and stores ordered under contract; private-wire teleprinter circuits; fire alarm circuits; and railway block signalling equipment and circuits. He became staff engineer, Broadcasting Section, in 1949 working on broadcast transmitters, medium- and short-wave equipment, and studio equipment. He retired in 1951 to take a position as commercial engineer and technical and industrial advisor in private business. Mr. Ferguson is a member of the Institution of Electrical Engineers, Great Britain, having served as chairman of the Irish Branch and now as local honorary secretary, and the Institute of Radio Engineers.

Albert P. Godsho (AM '16, M '22, Member for Life), engineer of transmission and protection, The Bell Telephone Company of Pennsylvania, Philadelphia, has been transferred to the grade of Fellow in the AIEE "for distinguished service in contributing significantly to the high standard of performance of the telephone and radio facilities serving an important area of the nation." Mr. Godsho was born in Philadelphia, Pa., July 29, 1894, and graduated from the University of Pennsylvania in 1914 with a bachelor of science degree in electrical engineering. He joined The Bell Telephone Company of Pennsylvania after graduation as an engineering assistant, first handling routine outside plant engineering problems and then being engaged on toll cable, interoffice trunk cable, and loading studies, both from a technical design standpoint and from the standpoint of making cost analyses preparatory to choosing one from a number of plans. In 1921 he became assistant engineer of transmission, assigned to general supervision of design of toll and interoffice trunk cable. He became engineer

Glen Ireland

of transmission and protection in 1926 responsible for all transmission and protection engineering for the city of Philadelphia. The territory involved was enlarged subsequently, today comprising not only Philadelphia but also adjacent counties in Pennsylvania and the State of Delaware. Mr. Godsho's responsibilities cover toll and trunk cable design; inductive co-ordination; protection against power and lightning exposures; design of off-premises extension stations; foreign exchange lines, tie lines, program circuits, and other miscellaneous uses of the telephone plant; loop and trunk studies to determine the distribution of transmission losses as affected by improved station equipment; higher cutoff loading systems; finer wire cables; traffic operating methods; and radio communication engineering, including coastal harbor, mobile, radio relay, and program, both audio and television. Mr. Godsho has served on the AIEE Committees on Electronics (1945–47) and Wire Communications Systems (1952–53) and is a member of the Institute of Radio Engineers and the Acoustical Society of America.

Glen Ireland (M '31), vice-president, Personnel Department, Pacific Telephone and Telegraph Company, San Francisco, Calif., has been transferred to the grade of Fellow in the AIEE "for outstanding contributions in the planning and basic design of the nationwide telephone system, in particular the transmission and switching aspects of long distance service." Mr. Ireland was born in Independence, Iowa, September 4, 1895, and graduated from the University of Iowa in 1917 with a bachelor of science degree in electrical engineering. After 2 years in the United States Army as an officer, he was associated with Northwestern Bell Telephone Company, Des Moines, Iowa, for 3 years. From 1923 until 1946 he was with the Department of Operation and Engineering, American Telephone and Telegraph Company, New York, N. Y. Among the many important jobs for which he was responsible during this period was the engineering study directed to the introduction of the general toll switching plan. Mr. Ireland also was involved in studies on the development and application of cable networks and with the initial installations of coaxial cable and type *L* carrier system. He carried out technical studies of the transmission designs to be used in the number *4* toll crossbar systems which played an important part in the decision to use 4-wire switching. He became vice-president of the Pacific Telephone and Telegraph Company, San Francisco, in charge of rate and regulatory matters in 1947. He was responsible for the preparation of all material presented in cases for increased telephone rates before the Public Utilities Commissions in five western states. In 1949 he became vice-president and general manager of the Northern California and Nevada Area. In 1950 he was appointed assistant to the administrator of the National Production Authority, Washington, D. C., and was promoted to deputy administrator in 1951. Later that year he returned to Pacific Telephone and Telegraph and soon was assigned as vice-president, Personnel Department. Mr. Ireland is a member of Sigma Xi and Tau Beta Pi and has served on the AIEE Committee on Education (1939–40).



David W. McLenegan

David W. McLenegan (AM '24, M '31), manager, technical personnel and education, Nucleonics Division, General Electric Company, Richland, Wash., has been transferred to the grade of Fellow in the AIEE "for important developments and contributions in air conditioning, aircraft heat exchangers, transformer cooling, and heat pumps." Mr. McLenegan was born in Milwaukee, Wis., June 30, 1900, and graduated from the University of Wisconsin in 1921 with a bachelor of science degree in mechanical engineering. After teaching for a year, he joined the General Electric Company in Schenectady, N. Y., as a research assistant and later as an application engineer, Industrial Engineering Department. During this time he developed and tested turbine shaft packings; investigated shaft vibrations; studied synchronizing problems; developed resynchronizing controls for large synchronous motors; and developed and conducted an application engineering training course for junior engineers. When the Air Conditioning Department was formed in 1932 he joined it as assistant commercial engineer. He remained with the department until 1948, holding various engineering positions. His major contributions during this period included studies of power generation and control for railway car air-conditioning systems; developments in electric-driven heat pumps, including use of various heat sources, use of heat storage, and capacity modulation to improve load characteristics; development of a new type of air-to-air heat exchangers for military aircraft; development of compact cooling for large power transformers and rectifiers; analysis of new electric heat pump systems, using heat storage with multiple-effect compression. He was also responsible for appraisal of engineering personnel needs, recruiting, and placement of engineering personnel for the department. Since 1948 he has been manager of technical personnel and education for the Nucleonics Division, Richland, responsible for appraisal of all scientific and engineering personnel needs, selection, and recruitment; and development and conduct of graduate-level program of scientific and engineering education. Mr. McLenegan is a member of the American Society for Engineering Education, the American Institute of Chemical Engineers, and The American Society of Mechanical Engineers. He has served on the AIEE Committee on Education (1951–53).

AIEE PERSONALITIES....

N. S. Hibshman (AM '27, F '41), Assistant Secretary, AIEE, New York, N. Y., was elected secretary of Engineers' Council for Professional Development (ECPD) at the ECPD Annual Meeting recently for the year 1953–54. ECPD is a federation of eight engineering societies, each of which has three representatives on the council. The secretaryship is rotated on a year-to-year basis among five of the constituent societies which have headquarters in New York City. Mr. Hibshman succeeds C. E. Davies, Secretary of the ASME, who served as secretary of the council last year. S. L. Tyler, secretary of the AIChE, was elected assistant secretary of the council, with the view toward succeeding Mr. Hibshman at the conclusion of his term of office one year hence.

N. S. Hibshman

M. D. Hooven (AM '24, F '44), electrical engineer, Public Service Electric and Gas Company, Newark, N. J., was elected vice-chairman of Engineers' Council for Professional Development (ECPD) at the ECPD Annual Meeting recently. Mr.

M. D. Hooven

D. D. Ewing

R. H. Barclay

Hooven previously had been appointed an ECPD representative by the AIEE Board of Directors. Mr. Hooven was born on May 30, 1897, in Weatherly, Pa., and was graduated from Bucknell University in 1920. After a year in the employ of the Westinghouse Electric Corporation, he became manager of the radio department of the Robbins Electric Company, Pittsburgh, Pa. He became associated with the Public Service Electric Company in 1922 as one of a group engaged in the planning and design of the 132-kv system. He handled assignments in transmission and substation work, receiving the title of assistant transmission and substation engineer in 1939. Since 1942 he has held the position of electrical engineer in the electrical engineering department. Mr. Hooven is a member of the Institute of Radio Engineers and the National Society of Professional Engineers. He is serving as Vice-President, District 3, of the Institute, and has served previously as director (1948–52), and on the following committees: Technical Program, Board of Directors, Planning and Co-ordination, Institute Publicity, Award of Institute Prizes, Board of Examiners, Edison Medal, Finance, Technical Operations, Executive, Publication, and Public Relations.

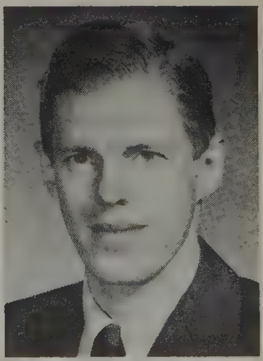
D. D. Ewing (AM '11, F '21, Member for Life), head, School of Electrical Engineering, Purdue University, Lafayette, Ind., has been appointed by the AIEE Board of Directors to serve as an AIEE representative on Engineers' Council for Professional Development. Dr. Ewing was born on October 7, 1883, and was graduated from Ohio Northern University in 1905. In 1907 he became an instructor in electrical and mechanical engineering there. In 1912 he entered Purdue University as a graduate student and a year later was appointed assistant professor of electrical engineering. He was appointed associate professor in 1916 and professor in 1918. He became head of the School of Electrical Engineering in 1942. In 1936 he received an honorary degree of doctor of engineering from Ohio Northern University. Dr. Ewing is a Director of the Institute and has served on the following AIEE committees: Electric Welding, Power Transmission and Distribution, Land Transportation, Code of Principles of Professional Conduct, Volta Scholarship Trustee, Edison Medal, Student Branches, Constitution and Bylaws, and Hoover Medal Board of Award. Dr. Ewing is a member of the American Society for Engineering Education, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

R. H. Barclay (AM '14, F '28, Member for Life), vice-president in charge of engineering, J. G. White Engineering Corporation, New York, N. Y., has been appointed by the AIEE Board of Directors to serve as an AIEE representative on Engineers' Council for Professional Development. Mr. Barclay was born in St. Louis, Mo., August 10, 1887, and attended Washington University. He spent the early part of his career working for electrical companies in Missouri. Coming to New York, he joined the Brooklyn-Manhattan Transit Corporation in 1915 as assistant electrical engineer. From 1917 to 1922 he was chief electrical engineer for The Foundation Company, New York, N. Y. After associations with Starrett and Van Vleck, Architects, New York, N. Y., the Stone and Webster Corporation, Boston, Mass., and McClelland Barclay Art Products Inc., New York, N. Y., he was appointed to the Federal Power Commission in 1934. He joined J. G. White in 1941 as electrical engineer in charge of the electrical engineering department. He became engineering manager in 1950 and vice-president in charge of engineering in 1953. Mr. Barclay is serving on the AIEE Board of Examiners and previously has served on the Marine Committee.

W. D. Coolidge (AM '10, M '34, Member for Life), consultant, General Electric Company, Schenectady, N. Y., was honored on his 80th birthday recently for his achievements in X-ray technology, powder metallurgy, lighting, and industrial cutting tools by his friends and associates and four General Electric departments. Dr. Coolidge, former vice-president and director of research for the General Electric Company, is noted chiefly for his discovery in 1908 of a means of making tungsten into a pliable metal which could be used in lamp filaments, radio tubes, X-ray tubes, and many other places. He was born in Hudson, Mass., October 23, 1873, and received a bachelor of science degree in electrical engineering in 1896 and a doctor of philosophy degree from the University of Leipzig (Germany) in 1899. Dr. Coolidge joined the General Electric Research Laboratory in 1905 and 3 years later was made assistant director of the laboratory. He became director of the laboratory in 1932 and remained as vice-president of the company and director of research until his retirement in 1944. Since his retirement Dr. Coolidge has been consultant in X rays for the laboratory. He holds seven honorary degrees from various universities and is the winner of many awards including the Edison Medal (1927), and the Washington Award

W. D. Coolidge

O. W. Titus



G. C. Newton, Jr.

(1932). He served the AIEE on the Electrophysics and Edison Medal Committees.

O. W. Titus (AM '29, F '44), vice-president and general manager, Canada Wire and Cable Company, Ltd., Toronto, Ontario, Canada, has been elected president of the Canadian Electrical Manufacturers Association for 1953–54. Mr. Titus was born in Weston, Ontario, and graduated from the University of Toronto. He began his career as sales engineer for the Standard Underground Cable Company of Canada, Ltd., a predecessor of the Canada Wire and Cable Company. In 1929 he became cable engineer for the company and in 1935 was made chief electrical engineer in charge of all design and development engineering for all classes of power cable. Mr. Titus is a member of the Engineering Institute of Canada and the Association of Professional Engineers of Ontario. He has served on the following AIEE committees: Technical Program, Public Relations, Power Transmission and Distribution, and Insulated Conductors.

G. C. Newton, Jr. (AM '42, M '51), associate director, Servomechanism Laboratory, Massachusetts Institute of Technology, Cambridge, was awarded the Louis E. Levy Medal by the Franklin Institute for his paper "Compensation of Feedback Control Systems." Dr. Newton was born in Milwaukee, Wis., in 1919 and graduated in 1941 from Massachusetts Institute of Technology with a bachelor of science degree. He received a doctor of science degree in electrical engineering in 1950. Dr. Newton became an instructor in electrical engineering at Massachusetts Institute of Technology in 1946, assistant professor in 1949, and associate professor in 1952, a position he still holds. In addition to his teaching and laboratory work, Dr. Newton carries on a consulting practice in the field of automatic control. He also has served as an engineer of the York Safe and Lock Company and as project engineer of the Sperry Gyroscope Company. He is a member of the Institute of Radio Engineers.

H. T. Faus (AM '24, F '52), consulting engineer, Meter and Instrument Department, General Electric Company, Lynn, Mass., has been awarded his 50th United States patent. Through his inventions Mr. Faus has advanced the art in nearly all Meter and Instrument Department product lines. In addition, he made advances in sound recording and reproducing systems and high-frequency magnetic circuits used by the Electronics Division and in electrocardiograph recorders used by X ray. Mr. Faus has been with General Electric since 1922, with all but the first year on test spent in the Meter and Instrument Department.

G. L. Jones (AM '52) and **T. J. Lisy** (AM '52) have been assigned to the Newark, N. J., and Pittsburgh, Pa., sales offices, respectively, of the Reliance Electric and Engineering Company. Mr. Jones joined Reliance 3 years ago following graduation with a bachelor of science degree in electrical engineering from Lehigh University. Since then he has been assigned to sales and engineering work at the company's home offices in Cleveland, Ohio. A native of Cleveland, Mr. Lisy joined Reliance earlier this year with 4 years of electrical engineering experience in industrial and municipal assignments. He is a graduate of Case Institute of Technology and also holds a masters degree in business administration from Western Reserve University.

R. G. Dobbin (AM '46), motor consultant, International General Electric Company, Schenectady, N. Y., and Brazil, has joined the commercial motor section of Jack and Heintz, Inc., Cleveland, Ohio, as design engineer. Mr. Dobbin holds a bachelor of science degree in electrical engineering from the Milwaukee School of Engineering and is registered as a professional engineer in Indiana. For more than 10 years he served as a designer of fractional-horsepower motors with General Electric.

H. C. Frost (AM '35), head, engineering planning, Corn Products Refining Company, Chicago, Ill., has been appointed assistant chief engineer. Mr. Frost received his bachelor of science degree in electrical engineering from the University of Toledo. Before joining Corn Products in 1945 Mr. Frost was with Leeds and Northrup. He is a member of the Instrument Society of America.

B. R. Lester (AM '42), section engineer, and **J. P. Jordon** (AM '42, M '52), section head, Electronics Laboratory, General Electric Company, Syracuse, N. Y., have been named manager of advanced products development engineering and manager of components development engineering, respectively, in the expanded Electronics Laboratory. Mr. Jordan has served on the AIEE Committee on Electronics (1945–47, 1952–53).

Nasiruddin (AM '53), engineer, Department of Water and Power of the City of Los Angeles, Calif., has returned to India to his position as a member of the faculty of the Muslin University of Aligarh, India. Mr. Nasiruddin came to the United States upon the invitation of the Los Angeles Department of Water and Power to observe the operation of Hoover Dam and Los Angeles Water and Power projects in 1949. While in Los Angeles he obtained the degree of bachelor of electrical engineering from the University of Southern California.

H. R. Wilson (AM '47), sales representative, Allis-Chalmers Manufacturing Company, Indianapolis (Ind.) district office, has been named manager of the company's Rockford, Ill., branch office. A graduate electrical engineer of Rose Polytechnic Institute, Mr. Wilson has been associated with Allis-Chalmers since 1947.

A. M. Rothman (AM '50), electrical engineer, Morganite, Inc., Long Island City, N. Y., has been appointed district sales engineer for American Silver Company, Inc., Flushing, N. Y. Mr. Rothman holds a bachelor of electrical engineering degree from the College of the City of New York.

J. T. Madill (AM '41, M '48), Aluminum Company of Canada, Ltd., Montreal, Quebec, Canada, has been transferred to Kitimat, British Columbia, where he will be manager of power operations in British Columbia for Aluminum Company of Canada, Ltd. Mr. Madill is a member of the AIEE Committee on Power Generation (1947–53).

H. B. Reynolds (M '41, F '47, Member for Life), engineer, J. G. White Engineering Corporation, New York, N. Y., has left the employ of that company and will devote his time to technical writing and consulting work. Mr. Reynolds had been associated with J. G. White since his retirement from the position of superintendent of power generation for the New York City Transit System in 1949. He has served on the AIEE Committee on Power Generation (1943–46).

A. J. Wahl (AM '46), formerly major, United States Air Force, Wright-Patterson Air Force Base, Dayton, Ohio, has joined the staff of the Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md. Dr. Wahl is a native of Saxman, Kans., and received his bachelor of science degree in electrical engineering from the University of Kansas and his doctorate in electrical engineering from Princeton University.

W. L. Emery (AM '37, M '46) and **H. N. Hayward** (AM '29), associate professors of electrical engineering, University of Illinois, Urbana, have been promoted to the rank of professor. **L. O. Brown** (AM '51) and **H. E. Koenig** (AM '48), instructors in electrical engineering, have been advanced to assistant professor.

OBITUARY • • • •

Walter A. Giger (AM '41, M '48), application engineer, Allis-Chalmers Manufacturing Company, Norwood, Ohio, died September 25, 1953. Mr. Giger was born in Zurich, Switzerland, December 18, 1895, and graduated from the Swiss Federal Institute of Technology in 1920 with state diploma as an electrical engineer. The next year he was employed as an engineer in the Traction Department, Brown Boveri Company, Baden, Switzerland. From 1921 to 1923 he was an electrical engineer with the Grison Power Company, Chur, Switzerland. Following a year with the Skoda Stee Works, Pilsen, Czechoslovakia, he came to the United States in 1924 as a designing engineer, Locomotive Department, Genera Electric Company, Schenectady, N. Y In 1925 he became associated with the American Brown Boveri Company, Camden N. J., as electric traction engineer. He joined Allis-Chalmers Manufacturing Company, Milwaukee, Wis., in 1931 as electric traction engineer in charge of design and sale of electric and diesel-electric traction equipment. He returned to Switzerland in 1937 as chief engineer and procurist, Oerlikon Manufacturing Company, Zurich. In 1942 he was made chief engineer of the Railway Engineering Department, Brown Boveri Company, Baden. He returned to Allis-Chalmers in 1947. Mr. Giger was a member of the Swiss Electrical Engineers Association and the Engineers Association of the Institute of Technology. He had served on the AIEE Committee on Transportation.

Charles Lambert Kinsloe (AM '08, M '13, Member for Life), retired, Pennsylvania State College, State College, died October 14, 1953. Mr. Kinsloe retired in 1944 as head of the Department of Electrical Engineering of the college. He was born October 15, 1881, in Lock Haven, Pa., and received his bachelor of science degree in electrical engineering from Pennsylvania State College in 1903 and the electrical engineering degree in 1907 from the same institution. Meanwhile he was a student engineer with Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation), East Pittsburgh, Pa., an engineer with the Philadelphia Electric Company, and an instructor in electrical engineering at the University of Pittsburgh. He came to Pennsylvania State College in 1907 as acting head of the Department of Electrical Engineering and 2 years later was made head of the department, a position he held until his retirement. Mr. Kinsloe was a member of Phi Kappa Phi, Sigma Xi, Eta Kappa Nu, and the Society for the Promotion of Engineering Education. He had served on the AIEE Committees on Production and Application of Light (1926–33) and Education (1927–28, 1931–35).

Glenn Worth McCracken (AM '22, M '38), chief engineer, Birmingham Division, Alabama Power Company, died October 1, 1953. Mr. McCracken was born in Hoxie, Kans., December 20, 1893, and graduated from Kansas State College in 1919 with a bachelor of science degree in electrical engineering. After completing the General Electric Test Course, he joined the General Electric Company of Cuba as a sales engineer. In 1921 he became associated with Cia. de Alumbrada y Traccion, Santiago de Cuba, as an electric engineer. In 1924 he became district manager for Cia. Cubana de Electricidad, Manzanillo, Cuba, becoming superintendent and engineer in 1925. In 1926 he became distribution engineer for the Birmingham (Ala.) Electric Company. He became electrical engineer in 1930 and chief engineer in 1935, retaining this position when the company became a division of the Alabama Power Company.

Merton Maine Cory (AM '15, M '30, F '40, Member for Life), professor emeritus of electrical engineering, Michigan State College, East Lansing, died September 26, 1953. Professor Cory had retired in 1948. He was born in Nashua, N. H., August 18, 1882, and received his bachelor of science degree in electrical engineering from New Hampshire College (now the University of New Hampshire) in 1908 and the degree of electrical engineer from the same school in 1913. He received his master of science degree from the University of Michigan in 1933. Following his graduation he was with the General Electric Company, West Lynn, Mass., for 2 years, and then in 1912 went to Michigan State College as an instructor in electrical engineering. He became assistant professor in 1915, associate professor in 1918, and professor in 1937. Professor Cory was a former president of Tau Beta Pi and a former chairman of the Michigan Section of the AIEE.

Robert Bonner Jack Brunn (AM '34), section head and engineering supervisor, Hazeltine Electronics Corporation, Little Neck, N. Y., died July 30, 1953. Mr. Brunn was born on March 3, 1911, at Hazelton, Pa. He graduated from Lafayette College in 1932 with a bachelor of science degree in electrical engineering and received a masters degree from Massachusetts Institute of Technology in 1933. Following his graduation he worked for several small manufacturers of broadcast radio receivers and joined Hazeltine Electronics Corporation in 1936 and was engaged in research and development work on broadcast receivers. He joined the group working on television problems in 1938. From 1939 to 1941 Mr. Brunn worked in the Chicago, Ill., laboratories of the company. During World War II, he worked on air-borne electronic equipment and after the war on air navigation and traffic control equipment. Mr. Brunn was a member of Phi Beta Kappa and the Institute of Radio Engineers.

George W. O'Keeffe (M '46), assistant sales manager, Allis-Chalmers Boston Works, Hyde Park, Mass., died October 9, 1953. Mr. O'Keeffe was born in Dorchester, Mass., April 10, 1899, and attended Tufts College. From 1920 until the company was acquired by Allis-Chalmers in 1931 Mr. O'Keeffe was associated with Condit Electrical Manufacturing Corporation, Boston, Mass., in design and application engineering of circuit breakers. From 1931 to 1938 he managed the motor control department of Allis-Chalmers Boston Works. In 1938 he became sales application engineer on circuit breakers and in 1943 became sales engineer in charge of circuit breaker sales. Mr. O'Keeffe was a member of the National Electrical Manufacturers Association.

MEMBERSHIP . . .

Recommended for Transfer

The Board of Examiners at its meeting of October 15, 1953, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Armour, W., superintendent, hydro div., Windsor Utilities Commission, Windsor, Ontario, Canada
Asselstine, J. J., plant engineer, Falconbridge Nickel Mines, Ltd., Hardy Mine, Levack, Ontario, Canada
Balsdon, E. J., planning engineer, MBW area, New York Telephone Co., New York, N. Y.
Barnes, H. O., electrical engineer, Sangamo Electric Co., Springfield, Ill.
Baudry, R. A., manager, mechanical development section, Westinghouse Electric Corp., East Pittsburgh, Pa.
Blytheman, G. C., associate cable engineer, Detroit Edison Co., Detroit, Mich.
Bourlon, A. L., manager, central station dept., Industria Electrica de Mexico, Mexico, Federal District, Mexico
Brand, O. H., plant superintendent, Kramer power station, Nebraska Public Power System, Bellevue, Nebr.
Briggs, R. H., electrical engineer, Eastman Kodak Co., Rochester, N. Y.
Brinton, R. L., communications superintendent, Pacific Gas & Electric Co., San Francisco, Calif.
Campbell, C. D, senior electrical engineer, Humble Pipe Line Co., Houston, Tex.
Cook, A. C., engineer, industrial engg. div., General Electric Co., Schenectady, N. Y.
Cox, J. C., electronics project engineer, Norfolk Naval Ship Yard, Portsmouth, Va.
Fillmore, R. L., electrical engineering instructor, University of Minnesota, Minneapolis, Minn.
Graham, H., chief engineer, Public Utilities Commission, Victoria, British Columbia, Canada
Hand, E. J., deputy director, National Production Authority, Washington, D. C.
Hiers, W. A., switchgear engineer, Westinghouse Electric Corp., Dallas, Tex.
Hogan, J. C., associate professor of electrical engineering, University of Missouri, Columbia, Mo.
Kiburz, M. E., electrical supervisor, Omaha Public Power District, Omaha, Nebr.
Larissou, J. P., electrical engineer, G. M. Simonson, consulting engineer, 507 Howard St., San Francisco, Calif.
Lodge, E. A., superintendent, Saguaro station, Arizona Public Service Co., Phoenix, Ariz.
Lutz, W. E., chief, electrical design branch, Okinawa District Engineers, APO 331, c/o PM, San Francisco, Calif.
Mohr, M. E., head, E-series systems dept., Hughes Aircraft Co., Culver City, Calif.
Moore, J. T., Jr., chief, electrical section, U. S. Veterans Administration, Washington, D. C.
Moynihan, J. D., electric utility engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Muckley, C. J., electrical engineer, The Timken Roller Bearing Co., Canton, Ohio
Olmedo, J. H., professor-in-charge, electrical machinery laboratory, Universidad Nacional de Mexico, Mexico, Federal District, Mexico
Peltosalo, A. E., manager, market research & product planning, General Electric Co., Hudson Falls, N. Y.
Pies, J. R., executive vice-president, Industrial Development Engineering Associates, Inc., Indianapolis, Ind.
Prentice, W. H., commercial engineer, General Electric Co., Boston, Mass.
Quadri, N. H., executive engineer, Eastern Electrical Div., Ramna, Dacca, East Pakistan
Rands, O. O., manager, power div., U. S. Bureau of Reclamation, Sacramento, Calif.
Riall, E. C., Jr., asst. superintendent, compressor stations, Texas Eastern Transmission Corp., Shreveport, La.
Schultz, G. F., mechanical engineer, George A. Fuller Co., New York, N. Y.
Strauss, F. E., manager, industry control dept., General Electric Co., Oakland, Calif.
Switzer, D. C., assistant to superintendent of engineering, The Hartford Electric Light Co., Hartford, Conn.
Switzer, G. F., chief engineer, Indianapolis Power & Light Co., Indianapolis, Ind.
Tallman, S. R., engineer, Narragansett Electric Co., Providence, R. I.
Tombaugh, S. J., manager, Toledo office, General Electric Co., Toledo, Ohio
Totah, E. J., engineer, Vitro Corporation of America, Silver Spring, Md.
Walchli, H. E., engineer, C & CCC, Oak Ridge National Laboratories, Oak Ridge, Tenn.
Webb, J. M., assistant director, engineering div., Eli Lilly & Co., Indianapolis, Ind.

42 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before December 25, 1953, or February 25, 1954, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Anson, E. H. (re-election), Gibbs & Hill, Inc., New York, N. Y.
DuBois, J. H., Mycalex Corp. of America, Clifton, N. J.
Eschborn, R. J., Jack & Heintz, Inc., Cleveland, Ohio
Jackson, H. W., Ryerson Inst. of Technology, Toronto, Ontario, Canada

4 to grade of Member

OF CURRENT INTEREST

Electronic Speed Tally Reduces Time Needed for Inventory Control

A new electronic device that is expected to speed inventory control in business and industry, reducing to a fraction of a second the time needed to check an entire inventory, has been developed by Remington Rand Inc.

The new device, called the "Speed Tally," was demonstrated recently for the first time by John Plain and Company, Chicago, Ill., for whom the system was developed.

The system is housed in a small cabinet, about 7 feet long and 6 feet high, with ten keyboard devices that look like hand adding machines, which feed information into the system.

The Speed Tally receives tallies of orders, or inventory items, through the keyboards, and within 0.4 second it has added the new item to the existing total in its proper catalogue classification, and registered the new total. It can handle 13,000 items in each of three categories.

While the new device was developed primarily for the use of John Plain and Company in tallying orders in its widespread mail-order system and keeping the information up to date so that it can be of use to buyers, the possible applications of the Speed Tally are expected to be far reaching.

Remington Rand's electronic experts believe it will be of great use, with certain modifications, for keeping a perpetual inventory control in any business or factory requiring such a service for a large number of catalogue classifications.

This would enable management of a factory, warehouse, or any storage system requiring accurate inventory of large numbers of items of various types, to keep a constant record of all additions and subtractions, with immediate access to current inventory information.

The system has four basic phases of operation—an input through the keyboard; a magnetic memory or storage drum, where the new item is matched with the previous total in the proper catalogue classification; an arithmetic section which performs the addition and subtraction; and an output which, on demand, records the new total on a printing device.

This is the way the Speed Tally works:

An operator at one of the keyboards receives an order, and presses the proper keys to indicate the number of items and the catalogue classification number. As fast as she completes one operation, she can start on the next because the Speed Tally has already processed the information through the magnetic memory, added (or subtracted) the items in the proper categories, and displayed the new totals on a visual indicator panel—all in less than a half-second.

At the time a record of the tally is wanted, a punched paper tape is inserted in the tape reader unit and the tallies of those items specified on the particular tape are printed on an adding-machine type of paper tape.

The nerve center of the system is the magnetic memory, developed by Remington Rand's Engineering Research Associates Division for the giant electronic computers and many other systems.

This is a rotating drum, with magnetized channels around the circumference and along the longitudinal surface of the drum. Each catalogue number has an address on the drum, where the existing total is registered. When the new item is processed into the drum, the entire system is scanned for the catalogue number address and the new total is added to the proper catalogue number.

This new total is carried to the output system, and the operation is completed by the return of the latest total to the address of the catalogue classification on the drum, where it is ready for the addition of subsequent entries. The entire operation requires approximately 0.4 second.

Since each operation is performed in a fraction of a second, the Speed Tally is always ahead of any operator. Each of the input keyboards is scanned in succession, and by the time the system has run through nine keyboards, in less than 5 seconds, the tenth operator will have a new entry ready for tallying.

As a comparison between the Speed Tally and previous systems, when a customer's order came in for a group of items, under the old system the clerk had to find the correct tally book for that catalogue number in a file of huge books, flip to the right page, mark down the entry to indicate that the item had been ordered. The information then had to be summarized for the benefit of buyers, as well as for inventory.

Under the Speed Tally System, the operator glances at the order, notes the quantity and type of items ordered, punches both on the keyboard, and the machine does the rest.

Future Meetings of Other Societies

American Physical Society. Winter Meeting. December 28–30, 1953, Stanford University, Stanford, Calif.

Exposition of Chemical Industries. 24th Exposition. November 30–December 5, 1953, Commercial Museum and Convention Hall, Philadelphia, Pa.

Institute of the Aeronautical Sciences. 17th Wright Brothers Lecture. December 17, 1953, United States Chamber of Commerce Building, Washington, D. C.

Mid-Century Conference on Resources for the Future. December 2–4, 1953, Shoreham Hotel, Washington, D. C.

The American Society of Mechanical Engineers. Annual Meeting. November 29–December 4, 1953, Statler Hotel, New York, N. Y.

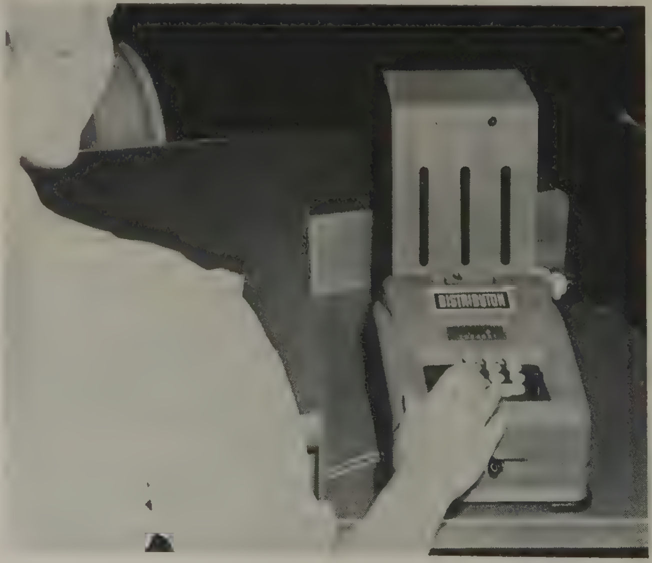
The American Society of Mechanical Engineers, Instruments and Regulators Division. Symposium on Frequency Response. December 1–2, 1953, New York, N. Y.

Wire and Cable Symposium. 2d Annual Symposium. December 14–16, 1953, Berkeley Carteret Hotel, Asbury Park, N. J.

If the management wants to know how many items of a certain type have been ordered at the end of the day, the operator merely punches the catalogue number on the keyboard and the total is printed on the output machine.

One of the features of the Speed Tally is what is known as the "automatic 1." In order to eliminate the time needed to punch the quantity when only one item in a catalogue classification is needed, the operator merely punches the catalogue number and the machine automatically registers a quantity of "1."

The Speed Tally also can separate tallies in different groups, through the use of a "category switch." Thus it is possible to record 13,000 tallies covering orders only, 13,000 covering cancellations, and 13,000 tallies on current inventory balances, giving a total of 39,000 different tallies.



One of ten 10-key keyboards that is hooked up to the magnetic memory. The operator feeds into the machine catalogue numbers with the quantity of the order which is added to the total stored within the memory

Moderate-Cost Navigational Radar Developed for Small Vessels

Navigational radar has become an accepted item of equipment for most long-range merchant vessels throughout the world today. Due to high cost, however, and to high power demands, space requirements, and like problems, it has not found its way aboard smaller commercial and pleasure vessels.

Raytheon Manufacturing Company's design engineers began work on this problem 3 years ago. Using an entirely new approach, they worked on plans for a radar that would retain all the "big ship" type of features and performance, yet would be small enough for fishing vessels, tugs, and similar small craft, at moderate cost.

The result of this design effort has culminated in the "Mariners Pathfinder"* Model *1500* radar. Its effectiveness is proved by the fact that it equals or exceeds the performance of other equipments on the market costing twice as much. It can serve therefore not only as a primary radar installation for yachts, fishing vessels, tugs, and other small craft, but also for ocean-going ships that heretofore have not been equipped with radar because of the cost.

The new Model *1500* also will serve ideally as stand-by equipment for first-line ocean vessels with operational and safety requirements requiring this additional protective measure.

Proof that the unusually low installed cost was not achieved through sacrifices in features and characteristics is found in this list of the Model *1500*'s features: parallel line cursor and bearing scale, projected onto the tube face through the Raytheon-developed reflection plotter; built-in test meter which gives instant check of system performance; 10-inch plan position indicator with range scales of 1, 2, 4, 8, and 16 miles.

The Model *1500* radar is made up of just two units, requiring only three interconnecting cables for the entire system and completely eliminating waveguide.

The elimination of waveguide is made possible by including the transmitter in the antenna assembly. Such elimination has benefits other than merely reduced costs. The power transmission losses through a waveguide system are considerable, and the elimination of this loss has the same effect as a substantial increase in transmitter power. The gain from this source coupled with that of a balanced crystal mixer, a most recent development in radar receiver practice, enables the use of a low-power transmitter (7-kw peak power) while getting detection ranges equivalent to a 40- or 50-kw transmitter in previous conventional radar systems. Elimination of the waveguide also makes possible outstanding minimum range performance. The radar is capable of detecting targets at ranges of 50 yards or less.

Another high-cost item in previous radars was that of special motors with complex and costly gear-reducing units especially designed for rotating antennae. The solution to this problem was to choose a stock, 1/4-horsepower motor which drives the antenna through a "V" belt. For high accuracy and reliability, a standard synchro system is used to convey antenna rotation data to the indicator.

System elements which are located in the antenna include the magnetron, local oscillator, transmitting-receiving tube, balanced crystal mixer, and cascade preamplifier. The remainder of the receiver and of the system power supplies are located in the indicator. Previous radar equipments have employed receivers with automatic frequency control. Raytheon's engineers have developed for the first time, in this system, a manual tuning system using a tuning meter which is positive and foolproof. This development eliminates from five to six tubes and a complex circuit which has been a common source of difficulty in radar systems and represents a considerable saving in the over-all system cost. A convenient tuning meter is incorporated in the indicator front panel so that the equipment tuning may be checked by the user. The stability of the circuit is such that once tuned, the receiver will stay peaked indefinitely. The tuning operation requires only 2 or 3 seconds and may be checked at any time without disturbing the operation of the system. Other circuit improvements and developments have made possible a reduction in the total number of tubes employed of 50 to 75 for previous systems to only 33 in this radar. This results not only in cost economies but also substantially reduces the power required for system operation and will minimize greatly the number of system outages due to tube failure.

Consideration also is given in the design to the selection of common tube types such as are employed in great quantities in radio and television receivers. This greatly reduces tube replacement costs and also makes it possible to obtain replacement tubes more readily.

Despite the strong emphasis on producing the lowest possible cost radar no sacrifice of quality or reliability has been permitted; high-quality components have been selected throughout the equipment and it has undergone the most comprehensive test schedule to assure that its design and construction is more than adequate for the rugged service which it will meet. It has been operated under temperature extremes from 20-degree-below-zero cold to 140-degree heat. The antenna has been wind-tunnel tested to assure that it will operate normally at winds up to 75 knots and will not suffer damage in winds of 100 knots and more. The entire system has been subjected to salt spray tests, days of torturing vibration and shock virtually equivalent to the Navy's requirements for combat equipment.

Ease of maintenance is another factor which has been considered paramount in its design. The tuning meter also serves as a system test meter so that the operator himself readily can check system performance and localize any difficulty that might arise. The indicator is accessible for service by merely undoing the lifting handle and swinging the cover to one side. This exposes all the system, tubes, fuses, and other components which can be replaced by ships' personnel. The transmitter unit is arranged for easy access and may be operated in the "open" position for minor adjustments in its installed location on the mast. For more comprehensive testing it is readily detached from the antenna so that it may be brought below to a location adjacent to the indicator where it may be operated for servicing by the use of simple jumper cables. The entire transmitter unit with its protective housing weighs but 16 pounds.

Reflection Plotter is part of the new Model 1500 "Mariners Pathfinder" radar for small vessels. The plotter casts bearing cursor and range scale readings onto scope face, where plot-marks can be made with china marking pencil without parallax error

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* Registered Trade Mark

William E. Wrather Awarded the John Fritz Medal

William Embry Wrather, past president of the American Institute of Mining and Metallurgical Engineers, and director of the United States Geological Survey, has been awarded the John Fritz Medal by unanimous choice of a 16-man board.

The medal is given annually for notable scientific or industrial achievement. In awarding the medal to Dr. Wrather, the board cited him as: "A geologist of world-wide experience and fame; and outstanding scientist and historian; a wise leader distinguished for his service to the nation."

Selection of Dr. Wrather was made by a board consisting of four members each from the four Founder Societies: American Institute of Mining and Metallurgical Engineers; American Society of Civil Engineers; The American Society of Mechanical Engineers; and the AIEE.

Dr. Wrather has traveled the Balkans, Africa, South America, and Asia in his professional status. In 1933 he helped organize the 16th International Geological Congress in Washington.

In the past Dr. Wrather has been a member of the Texas Historical Society and once served as its president. His collection of maps is famous.

ASEE-ECPD Meeting Stresses Importance of Growth of the Engineering Profession

The joint meeting of the American Society for Engineering Education (ASEE) and the Engineers' Council for Professional Development (ECPD) was held October 14–17, 1953, at the Statler Hotel, New York, N. Y. The theme of the meeting was "Civilization Is Dependent Upon the Growth of the Engineering Profession."

The first general session was the conference on Thursday morning, October 15, which dealt with creativeness in the arts. The first speaker was John Ferren, New York painter and teacher at Cooper Union and Queens College. He spoke of three phases in the process of creativity characterizing them as an intellectual sensibility, a moment of insight, and a time of energy which is beset with pitfalls and fears.

Virgil Thompson, composer and music critic for the New York *Herald Tribune*, discussed how a composer arrives at a musical design.

The last creative artist to speak was Ralph Bates, novelist and adjunct professor of literature at New York University's Division of General Education, who discussed at some length the creative process as revealed in the voluminous documentation left by Dostoyevski and Stendhal about their own ways of writing. He also spoke of artistic flashes followed by a period of considerable working and often much reworking.

In summation, Eric Walker—vice-president of ASEE and dean of engineering, Pennsylvania State College—who presided over the session, pointed out that the three phases of creation discussed could be called (1) the moment of illumination, the great idea, or "flash of genius"; (2) the doodling period; and (3) the period of working out the details. The first period apparently is not directly amenable to fostering or teaching whereas the second and third (the craft) can be taught and facilitated by research administrators.

L. E. Grinter, president of ASEE and dean of engineering and director of research, University of Florida, presided at the luncheon which was addressed by Morris I. Stein, professor of psychology, University of Chicago. His speech was entitled "A Psychologist Looks at Creativeness, Its Environment and Its Measurement." Several hypotheses were presented which had been developed in studying artists and were tested in a study of research chemists. These included the concept that a creative person may possess more sensitivity to the gaps existing in his culture so he can call attention to them or find a means of effecting closure. He must be able to tolerate ambiguity and maintain direction while developing and testing hypotheses. The role of the audience to whom the creative person must communicate was considered also. Specifically, the research chemists rated "more creative" by their superiors and colleagues showed greater freedom in offering perceptual hypotheses and in the level of organization of their responses in a test situation than their colleagues rated "less creative."

The afternoon conference, whose theme was creativeness in engineering, was presided over by W. L. Everitt, vice-president of ASEE and dean of engineering, University of Illinois. The first speaker was Fred Olsen, vice-president for research and development, Olin Industries, who presented the industrialist's point of view. He pointed out the need (1) to provide an environment and mental climate favorable to inventiveness, (2) to devise tests to select persons of inherent high order of creativity, (3) to aid educators in developing talented students and in improving the creativity of those not found initially to be resourceful, (4) to find a means of conserving our greatest natural resource: natural resourcefulness, and with these goals achieved the material well-being of peoples everywhere would be increased.

The engineering viewpoint was presented by Maurice Nelles, director of the Borg-Warner Laboratory. He discussed some of the methods he felt to be most promising for teaching or influencing engineering college students to be more creative, indicating that the important stimulants to creativity are reading, talking—including discussion, seeing, hearing, and doing, interspersed with time for thinking.

The second day was opened with a session devoted to engineering accrediting. The chairman was Thorndike Saville, ECPD Education Committee chairman and dean of engineering, New York University. The vice-chairman was Nelson Hibshman, Assistant Secretary, AIEE.

Ewald B. Nyquist, secretary of the Middle States Association, spoke on the National Committee on Accrediting, the Middle States Association, and the relations of their programs with that of the ECPD program of engineering accrediting.

Gregory Dexter, consulting engineer, talked on the topic of neglected future engineers, emphasizing the weaknesses of the present accrediting processes especially in not giving more guidance in selecting institutions of higher learning.

L. E. Grinter discussed the findings of the ASEE Education Evaluation Study as they relate to accrediting. Higher standards for accreditation were recommended, a division of engineering education into "professional-scientific" and "professional-general" education, and special designation for institutions with standards substantially above minimum. Humanistic-social studies should afford a "clearer perspective of civilization, inspiration for seeking greater knowledge and understanding, and aid in development of judgment and discrimination, a sense of value, and sound personal philosophy." It was pointed out that 4-year programs may not be sufficient to meet the committee's recommendations for the professional-scientific curriculum plus the specialized courses of the degree-granting department, but the committee felt "that specialized engineering courses are of far less value in professional-scientific education than a broad background of engineering science."

After considerable questioning and discussion from the floor a summary was made by S. C. Hollister, dean of engineering, Cornell University; past president, ASEE and former chairman, ECPD Education Committee.

Water problems on the Canadian–United States boundary were discussed by General A. G. L. McNaughton (HM '42), chairman, Canadian Section of the International Joint Commission, at the luncheon meeting on Friday.

The afternoon session, with T. H. Chilton chairman of the Engineering Manpower Commission, presiding, was devoted to post-college training and an engineering manpower utilization panel. Cornelius Wandmacher, chairman, ECPD Training Committee, professor of civil engineering, University of Cincinnati, discussed the plans and results of the ECPD experimental training program at Cincinnati with six basic points of endeavor: orientation and training in industry, continued education, integration into the community, professional registration, self appraisal, and recommended reading.

Guy Kleis, Westinghouse Electric Corporation, explained their 3-point program which includes (1) employing non-engineers for "fringe area" jobs; (2) purifying "engineering area" jobs, and (3) raising the performance level of both professional and supporting personnel through an educational assistance program.

Chester L. Brisley, chief industrial engineer, Wolverine Tube Division, Calumet and Hecla, Inc., explained and illustrated the work-sampling technique used by his company which requires less time and less trained personnel to obtain sufficiently accurate data.

The annual Engineers' Dinner was held Friday evening and presided over by Henry T. Heald, vice-chairman, ECPD, and chancellor, New York University. The ECPD annual report was given by Colonel L. F. Grant, chairman, ECPD.

Horace P. Liversidge, chairman of the board, Philadelphia Electric Company, spoke about industry and engineering education. In stressing that the engineering manpower shortage could be solved only by the joint effort of educators and industrialists, he concluded that industry should pay for its additional scientific and engineering personnel just as it now pays for its other facilities for doing business and that management has the responsibility for selling this to directors and stockholders.

Storage Battery Lowers Power Costs for Lift Bridge

The aerial lift bridge at Duluth, Minn., is raised by power derived from storage batteries. Up until 1930, the bridge carried automobiles and passengers across the canal connecting Duluth Harbor with Lake Superior on a special gondola suspended from the overhead span. Now a continuous span permits free flow of traffic. When an ore-boat approaches, the entire span is raised.

The huge battery, installed by Gould-National Batteries, consists of 153 Plante cells (rated at 800 ampere-hours for 8 hours) and raises the lift span 120 feet above water

Power for raising this bridge comes from 153-cell battery. Power for charging is taken from a public utility at constant rate with peak loads being absorbed by the battery

level in 55 seconds like a gigantic elevator. The center span is raised about 30 times per day or 3,000 lifts per year during the open-water season lasting from April to November. During a busy day, the battery may be discharged as much as 25 per cent of its capacity.

The batteries are charged by motor generators on current purchased from the Minnesota Power and Light Company. Inasmuch as the peak demand for electric energy to raise the span is accumulated by the battery and the motor-generator set operates at a constant rate, the peak-demand charge is low. The cost of electric energy is less than if the bridge-raising motors took power directly from the utility.

Dependability is another factor in using the large battery. The power is always available and cannot be interrupted by storms. A stand-by gasoline engine is available for charging the battery in event of a failure of the power lines but has been used only three times since 1930.

Error Voltage Detector Aids in Servo-Control Applications

A broad-band low-level error-voltage detector has been developed by the National Bureau of Standards (NBS). Utilizing crystal diodes in a bridge circuit, the device operates on the radio-frequency chopper principle and shows a resolution to 1 millivolt with a bandwidth of at least 1 megacycle. A zero drift stability to 1 millivolt is readily attainable. The Bureau's instrument provides an answer to the need for precise sampling in many servo-control applications.

Some of the most important and rapid technological advances of the past decade have been in the automatic control of machines and processes. Substantial further extension of this trend toward automatization in industrial and military technology seems highly probable. Many significant applications of automatic control are based on servo feedback systems. These systems may be thought of as arrangements in which any deviation of a controlled device or process gives rise to an error signal—usually an electric voltage. The servo system then initiates a corrective action which continues until the error signal is brought very nearly to zero, that is, until the desired condition is reached.

A crucial element of any servo system is the method or device used for sensing the error signal, which usually means detecting the difference between two voltages. Ideally, a signal detector should be able to measure the error signal immediately when the controlled process deviates from the desired condition by even the smallest amount, and to initiate remedial action in the shortest possible time. The need for greater response speeds in some servo applications has brought about a search for a detector which will make a more rapid sampling of the output than a mechanical vibrator or chopper with its limited frequency. The inertia characteristics of a mechanical device place a definite limitation on the over-all response speed. The chopper principle, however, must be retained in order that the error detector may respond to d-c signals as well as a-c signals up to video frequencies—a fundamental requirement of many servo applications.

In order to achieve a more rapid sampling rate, it was found necessary to eliminate the mechanical parts altogether and to use electronic circuit elements. Some sensitivity is sacrificed, but the speed of response of the system is tremendously increased. The best stability in an electronic circuit is usually obtained when only passive components are used in the critical parts of the system. At present, the germanium diode appears to be the best passive chopper element. When it is designed into a device that is self-compensating for temperature coefficients of the crystals, it is capable of unusual zero-drift stability.

Essentially, the NBS error-voltage detector is a bridge modulator with a radio-frequency carrier as its source and the modulating signal as a dynamic controller of resistive balance. High sensitivity for signals near zero in amplitude is the primary aim, and nonlinear reduction in sensitivity for signals departing from zero is both convenient and desirable. Two of the arms of the bridge are germanium diodes whose forward resistances are compared, and the other two arms are inductors which serve as radio-frequency voltage sources for excitation of the diodes. The usual difficulty with contact potentials in germanium diodes is minimized by having the crystals operate at a carrier voltage high compared to the contact potential.

During one half of the carrier cycle neither diode conducts and the output is zero. During the other half-cycle the output is still zero when the two diodes have the same forward resistance. But an error voltage applies a differential bias, unbalances these resistances, and causes a portion of the radio-frequency carrier to appear at the output. Thus the error voltage causes partial half-wave rectification of the radio-frequency source, and this output voltage itself contains a component at the radio frequency which is amplified and serves as the indication of the error-signal voltage.

Mechanical details are important in the design and construction of the detector. Excellent shielding between input and output circuits is essential, since a small leak from the radio-frequency source will reduce the sensitivity greatly. Adequate shielding is provided by milling the main body of the transducer from a block of aluminum. A solid partition between the milled-out cavities reduces radio-frequency leakage to a minimum, and thick walls furnish a heat sink for the two germanium diodes. The filters used in the circuit are well protected from stray fields of the bridge circuit; this makes it possible to achieve an unusually good null balance and thus insures high sensitivity.

The transducer is not limited to a 30-megacycle carrier frequency. The general principle is readily adaptable to the use of an ultra-high-frequency carrier and will extend the bandwidth of the instrument if desired. If less bandwidth is required, a lower-frequency signal may be utilized with consequent economy of construction.

The use of a radio-frequency carrier in combination with the transducer containing only passive elements makes multichannel operation unusually attractive with its complete freedom from switching transients. One possible practical scheme involves a rotating radio-frequency link coupling between a number of transducers and a single amplifier. All moving contacts are avoided, and it is merely necessary to sample synchronously the amplifier output coincident with the positioning of the link coupling. Moreover, this method of multichannel sampling permits the transducer units to be placed near the sources of the signals to be amplified. It is quite practical then to provide coaxial cable connections from the numerous units to a common point where the radio-frequency commutation into the amplifier is accomplished.

The flexibility, accuracy, and reliability which the NBS instrument provides should make it suitable for many applications in nucleonics and other processing plant operations where precise automatic controls are needed.

National Electronics Conference Attracts Record Attendance

An attendance of 6,881 was recorded at the ninth annual National Electronics Conference which met September 28–30, 1953, at the Hotel Sherman, Chicago, Ill.

The 98-paper technical program and 150 booths of exhibits stressed the 1953 conference theme "Electronics—Key to Progress." The technical program, made up of sessions on audio and microphonics, circuits, communication, computers, engineering management, filters, instrumentation, material and components, magnetic amplifiers, microwaves, mechanics, servomechanisms, television, transistors, tubes, and ultrasonics, was presented by scientists and engineers from the country's foremost universities, laboratories, and industries.

Hood for a Turbine

Skilled foundrymen of the General Electric Company are shown lifting a rough finished core from the pit where it was molded. This 120,000-pound core is a mixture of sand, clay, and pitch, and will form the inside contour of a casting which will be the upper hood of a turbine rated 100,000 kva

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Robert W. Galvin, executive vice-president of Motorola, Inc., addressed the conferees at luncheon, September 28. Speaking on "Our Opportunities and Responsibilities," Mr. Galvin outlined the growth and defined the progress of the electronics industry since its inception 35 years ago. He touched on some of the milestones in the history of the field and then went on to look into its future.

"Today, we find ourselves in the midst of an engineering scrubbing down process in our black and white television, and with the task still unfinished, we now find ourselves in color television," Mr. Galvin said.

He emphasized the tremendous difficulties faced by the industry in color television.

Mr. Galvin offered his opinion that present problems—limited color programs, small experimental screens, and high priced receivers—should be resolved within the next 2 to 4 years.

I. S. Coggeshall, director of planning, International Communications, Western Union Telegraph Company, speaking on "Electronics—Thou Most Admired Disorder," at the September 29 luncheon, told those attending the conference to combat the trend toward splinter societies which rapid technological advances have caused. Warning that specialization may cause them to miss significant developments in the profession as a whole, Mr. Coggeshall said, "In addition to coverage of our specialty, to each of us is due the more general and fundamental information which provides the stimulus needed collectively in all the individual branches."

At the luncheon on September 30, H. E. Richmond, chairman of the board, General Radio Company, spoke on "Opportunities and Responsibilities of Employment in the Electronics Field." Mr. Richmond called upon the educators and students attending the conference to prepare themselves adequately for their future positions in the electronics field. He pointed out that the "average engineer" will have to be satisfied with a minor status in the rapidly advancing and terrifically competitive field.

All technical papers presented at the conference will be published in volume 9 of the "Proceedings of the National Electronics Conference." This book will be available at a cost of $5 after January 15, 1954, and may be ordered from the National Electronics Conference, Inc., Karl Kramer, executive secretary, 852 East 83d Street, Chicago 19, Ill.

EMC Issues Statement on Universal Military Training

The Engineering Manpower Commission (EMC) of Engineers Joint Council has been concerned with manpower utilization problems since 1950 and has made comprehensive studies of the Selective Service System, of the military reserve structure and the philosophy behind that structure, and of the various plans and programs which have been advanced for manpower utilization in time of partial and full mobilization.

In its study of Universal Military Training (UMT), EMC has considered not only its inherent nature and implications, but also its probable and potential effects on the over-all manpower picture in any future partial or full mobilization.

In order to obtain the maximum contribution of engineers, scientists, and other specialized personnel to the national defense and to the national health, safety, and interest, EMC recommends that:

1. The instructional program for UMT emphasize the basic military subjects and minimize specialist training as being subject to rapid obsolescence.
2. In any implementation of UMT, the training programs be planned to provide a minimum dislocation of the processes of higher education so necessary to the technology of preparedness.
3. UMT be completely separated from the construction of our military reserve forces and be regarded merely as a part of the basic required education of our male populace.
4. Those who complete UMT be returned to civil life and the jurisdiction of the Selective Service System.
5. To give effect to recommendations 3 and 4, the statutory provision involving provisions for an obligated period of service in the military reserve forces as now contained in Section 4 (D) of the Universal Military Training and Service Act of 1951 (P.L. 51) be repealed.
6. The problems of constructing a realistic, voluntary, dependable, immediately available reserve be the subject of intensive study apart from any considerations of Universal Military Training.

High-Speed Facsimile Equipment Developed for Sending Messages

United States Navy high-speed facsimile equipment, model *CXRG*, is a developmental model which may be used to transmit virtually any kind of document almost instantaneously over long distances. The basic system was conceived by engineers of the Bureau of Ships. Development and construction was carried out under contract with the Radio Corporation of America and the Haloid Company.

Design of the equipment began about 3 years ago when it was determined that commercial high-speed facsimile equipment had certain disadvantages and lacked certain features essential from the Navy standpoint.

The Bureau of Ships found that equipment was needed which would accept copy without processing and would turn out finished copy without need of a "wet" developer or extensive processing. The Bureau also wanted a machine which would deliver copies that could be directly reproduced on standard office offset-type reproduction equipment. Previously developed equipment operating at the desired speed required the photographing of copy to be transmitted. It delivered copy of photographic film, requiring enlarging and printing before delivery to user. This necessitated expensive equipment, skilled personnel, darkroom facilities, and adequate storage space, and consumed valuable time, all of which the Navy sought to avoid.

The transmitting equipment operates as follows:

Copy is fed into a vacuum transport system equivalent to laying copy on a moving belt, and moved under a scanner at the rate of ten 9- by 12-inch pages per minute. The scanner is a flying-light spot-scanner cathode-ray tube. Light reflected from the copy is received by a photo multiplier. The resulting video signal is amplified and used to modulate a carrier signal which is transmitted either by radio or wire to the receiver.

At the receiver, the signal is sent into a video amplifier where the synchronizing pulses are separated. These pulses control the scanning rate of a second flying-light spot-scanner cathode-ray tube. By this means the receiver spot is synchronized with the transmitter spot. The signal is amplified to modulate the intensity of the light spot. Therefore, the intensity of light in the receiver is made identical to the intensity of light in the transmitter.

The image caused by these patterns is focused upon a sensitized Xerographic drum. Variations in intensity of the light spot cause variations in the surface electric charge of the exposed parts of the drum. After exposure a cloud of "dust," which is really an electrostatically charged dye powder developed, is sprinkled over the drum. This dust sticks to the drum at points where the charge remains and sticks proportionately to the charge.

The drum then is brought into contact with the paper, the dye powder is transferred to the paper, and the paper moved under an infrared heating lamp which seals the dye to the paper. Thus a sharp black-on-white finished image, a facsimile of the transmitted copy, is formed.

Radio or wire transmission facilities having speed or bandwidth capabilities of approximately 1/20 of that required for television are needed for this system.

The new development makes available a new source of high-speed high-capacity low-cost service. Areas of application will not be restricted to the military.

Architectural League Announces 1954 Gold Medal Exhibition

The Architectural League of New York has announced its 1954 National Gold Medal Exhibition. This will be the 57th annual exhibition to honor outstanding work in architecture and allied fields, including engineering, by awarding gold and silver medals and honorable mentions.

Work in engineering to be eligible for an award must show some visual aspect of building, either structural, mechanical, or electrical, and be characterized as a special or unusual contribution in design to the progressive development of structures. The Engineering Committee on Selection consists of Peter A. Strobel, chairman, Henry F. Richardson, Gilmore D. Clarke, Fred N. Severud, and L. Andrew Reinhard.

Preliminary submissions, consisting of photographs only, are open to December 31, 1953. A circular of information may be obtained from Peter A. Strobel, 70 West 40th Street, New York 18, N. Y.

Important New Alloy Added to Beryllium-Copper Group

A new alloy—Beryldur—having outstanding possibilities in the field of copper base materials was introduced as a new product by The Beryllium Corporation at the 35th National Metal Exposition and Congress.

Beryldur is a low-content beryllium-copper alloy whose potentialities are only beginning to be explored. It may be described as filling the gap of property ranges existing between the two basic groups of beryllium-copper alloys: the high-strength and the high-conductivity groups. What it does is combine features of both, uniting high-strength and hardness values with extraordinary toughness and good electrical conductivity.

This total combination is unique, and properties also may be varied at will by a simple heat treatment that is nearly foolproof, the new alloy being capable of working and moderate shaping after mill-hardening.

Matthew J. Donachie, president of The Beryllium Corporation, was responsible for a good deal of the research connected with Beryldur. He said the alloy, now being produced on a commercial scale, will play an important role in the field of materials engineering and serve in many new applications not covered adequately by other metals and alloys now in use. Beryldur is viewed, for one example, as a potential rival of bronzes and brasses.

Beryldur has a low beryllium content of only 1 per cent, about midway between the amounts contained in the high-strength and the high-conductivity groups. Classed as a wrought alloy, it carries a lower price than others in this group with higher beryllium content.

Its excellent formability in the heat-treatable temper gives Beryldur, in addition, one of its major advantages over other copper base alloys.

Beryldur was field-tested for a year by The Beryllium Corporation to prove its value before it was put into commercial production on a large scale.

Beryldur is produced in only two tempers in a calculated effort to simplify application and eliminate the confusion that sometimes arises over specifications. The two tempers are: heat-treatable and mill-hardened. The former is desirable where severe forming is needed or where peak physical properties of the alloy are essential. Mill-hardened Beryldur requires no heat treatment of finished parts.

Important applications of Beryldur are predicted for the electromechanical field, especially in the manufacture of springs and switches.

At the present time The Beryllium Corporation is producing the new alloy in strip form only. Beryldur soon will be made, however, as wire and rod.

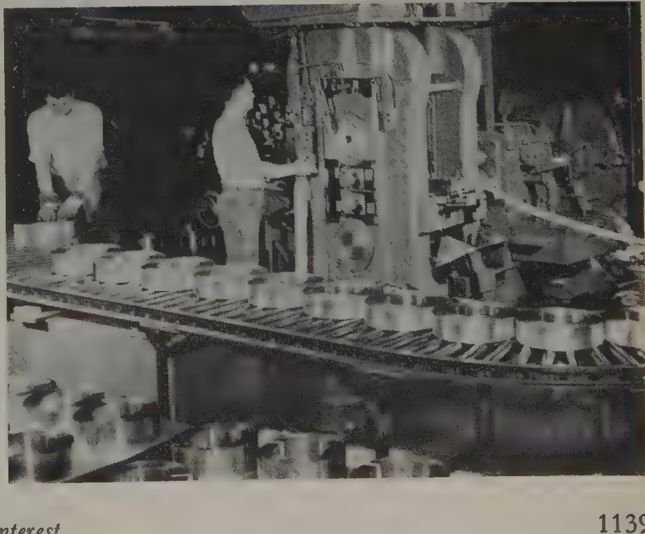
Turbidimeter Measures and Records Particles in Liquids

A new recording turbidimeter, which continuously and automatically measures and permanently records the number of particles suspended in liquids, has been announced by the General Electric Company's Special Products Section.

Developed for use in any process where turbidity is a significant factor, the device can be used with an audible or visible alarm. It provides readily available turbidity measurements for monitoring and controlling. Adjustable over a wide turbidity range, the turbidimeter has a splashproof construction and semi-null-balance system.

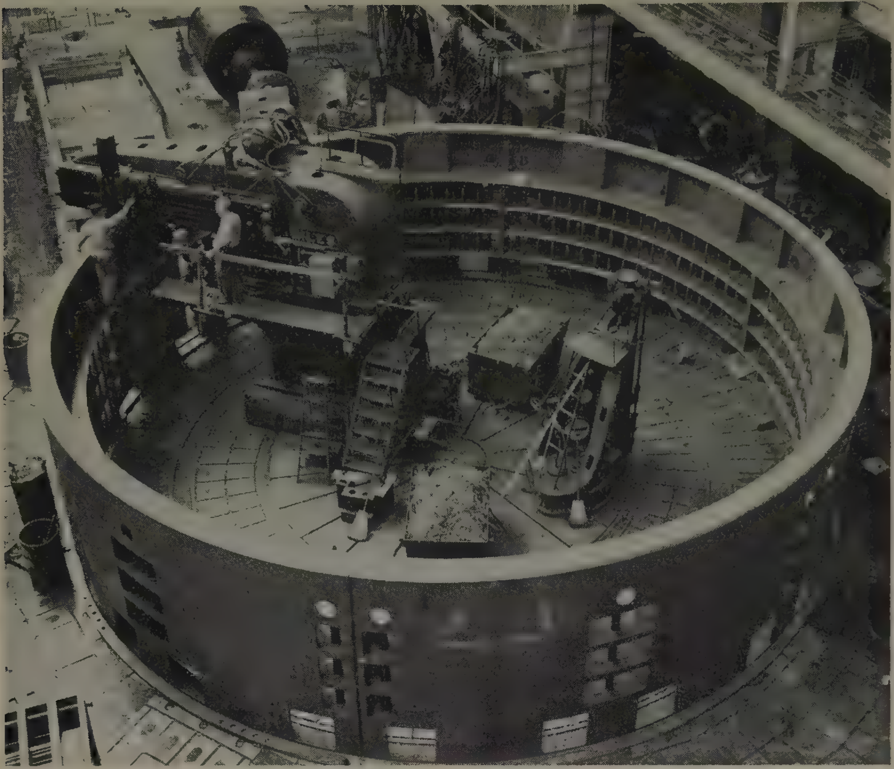
Specific applications include chemical and paper plants with private water supplies where turbidity has a direct effect on processes; monitoring of wastes dumped into streams and lakes to guard against pollution; water treatment plants where turbidity of incoming water determines the amount of flocculation chemicals to be added; detection of oil contamination in boiler feed water; soil erosion studies; and in any process where filter effectiveness must be constantly monitored.

The theory of operation is that if a liquid has no suspended particles, all light is transmitted while none is scattered so that the ratio of scattered to transmitted light is zero. As turbidity increases more light is scattered, less transmitted, and the ratio increases. The turbidimeter's detecting element is a single photovoltaic cell with current output proportional to the amount of light falling upon it. The light ratio is determined by computing the voltage output of the photocell when scattered light and then transmitted light are successively incident upon it.



Beryllium - copper alloy, Beryldur, is shown in cold-rolling operation

Stator Frame of Generator for McNary Dam



Stator frame of a hydraulic turbine-driven generator for McNary Dam on the Columbia River is shown on a 60-foot vertical boring mill of the General Electric Company. Rated at 73,684 kva, the generator, when assembled, will weigh 2,500,000 pounds. It is one of 12 which is being supplied for the project

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Indian Thermal Power Plant

The steam drum of one of four boilers is being hoisted into place at the Bokaro Thermal Power Plant now being built in India by the Kuljian Corporation. Ultimately, the station will operate on four 50,000-kw hydrogen-cooled turbogenerators and eight 300,000-pound-per-hour boilers. This is the first high-pressure steam-generating plant in the Far East

This is done by balancing the scattered light voltage against a battery, and at a later time balancing this remembered battery voltage against the transmitted light voltage. A range setting iris sets the photocell illumination in the transmitted light beam equal to the photocell illumination from the scattered light at any given point on the recorder scale where maximum accuracy is desired. This point of maximum accuracy may be 35, 70, or 100 per cent of full scale.

The resultant system is quite stable with respect to variations in photocell sensitivity, temperature, lamp brightness, line voltage, or color of the liquid.

Two main components make up the recording turbidimeter: a sampling head and a recorder. The sampling head contains the chamber through which the liquid passes and a single light source which illuminates a barrier-type photocell located on one side of the chamber. The light source is controlled by shutters so that it alternately shines through the sample chamber directly on the photocell and then at a right angle to the photocell. Thus the ratio measurement is made in such a way as to discount variations of the lamp or changing characteristics of the photocell due to aging or temperature changes.

A circular chart recorder is furnished as standard equipment and is remotely located from the sampling head. The recorder contains the memory circuit and measures electrically the ratio of scattered to transmitted light. This ratio is indicated by the recorder meter and is permanently marked on the chart.

With maximum operating pressure of 100 pounds per square inch inside the sampling head, the recording turbidimeter has an accuracy of +5 per cent of full scale and a precision +3 per cent of full scale. Range is adjustable in the field from 0–25 to 0–10,000 parts per million (silica scale). The sampling head requires 175 watts, 115 volts alternating current, and the recorder needs 55 watts at 115 volts alternating current. Cycle time is 60 seconds.

Photographic System Operates in Millionths of a Second

The development of a multiexposure microsecond photographic system—a super-camera with a "shutter speed" measured in millionths of a second—has been developed by electronics engineers at the Midwest Research Institute.

The scientists, Leon D. Findley, J. H. Van Horn, and Elbert S. Kennedy of the institute staff in Kansas City, Mo., presented a technical paper describing the system before the ninth annual National Electronics conference.

The new photographic device is expected to be extremely valuable in tasks of scientific investigation. In the field of scientific research, the engineers pointed out, it is often necessary to photograph objects or phenomena which change rapidly in position or characteristics. Use of the new photographic system will enable scientists to obtain sequence pictures in good detail of such actions as projectile in flight, blast studies, and other developments.

The device will record activity at speeds of one-millionth of a second and even smaller speeds under certain conditions. This unique photographic system which operates on electronic principles has been used satisfactorily at the institute. Extensive preliminary tests are being conducted.

Integral units of the new device are a timing-pulse source and driver, an energy storage and power supply, and a photographic recording instrument. The latter mechanism can be either a high-speed movie camera operating at 7,000 frames a second, more than 500 times as fast as normal movie camera speed, or a high-velocity drum-type camera.

The new photographic system was developed at the institute by applying new details and innovations to certain basic concepts, the engineers pointed out.

Seminar on Standardization to Be Held in January

Dr. John Gaillard, mechanical engineer, staff of the American Standards Association, and lecturer at Columbia University, will hold his next 5-day private seminar on industrial standardization from January 25 through 29, 1954, in the Engineering Societies Building, 29 West 39th Street, New York, N. Y.

The Gaillard Seminars were started in 1947 upon request from companies for assistance in the organization of their standardization work and the training of their men in writing standard specifications. More than 120 organizations have been represented so far.

The January 1954 session will consist of ten conferences, one in the morning, 9:30–12:00, and one in the afternoon, 1:30–4:00, Monday through Friday. At each conference a subject on the seminar program will be presented by Dr. Gaillard and then discussed around the table.

Further details concerning registration may be obtained from Dr. John Gaillard, 400 West 118th Street, New York 27, N. Y., or through the office of the American Standards Association, 70 East 45th Street, New York 18, N. Y.

Positions of Stars Measured and Recorded Automatically

A machine that automatically scans photographic plates taken of the heavens, identifies individual stars, and punches their position on IBM cards, has just gone into operation at the Watson Scientific Computing Laboratory. Professor Wallace J. Eckert, director of the laboratory which is operated jointly by Columbia University and the International Business Machines Corporation, headed a team of astronomers and engineers in the successful 6-year-long project. The unique "star factory" makes as many measurements in one day as a highly trained person does in a week—with an accuracy four times greater.

Photographic plates 17 inches square which contain the images of from 300 to 450 stars each are placed on the adjustable plate holder of the "measuring engine." From IBM cards the approximate location of individual stars, gotten from a previous star catalogue, is transmitted to selsyn motors. These motors move the appropriate image in front of a supersensitive photoelectric eye and the eye measures its exact position to within tenths of a micron. The exact position is then relayed back to the same card and punched on it.

In order to relate positions measured on the plate to the true positions in the sky elaborate computations are necessary. Electronic calculators can do this brainwork automatically, using the punched cards from the star factory. The resulting true positions then can be printed electrically and reproduced photographically—thereby completing the sequence of automatic operation.

This final step in mechanizing a once arduous and time-consuming part of astronomy will feed increasing amounts of data to theorists interested in the celestial mechanics of dimly seen, faraway stars. Some of the problems solved in building the star factory will be applicable also to automatic operation of machine tools and to manufacturing plants.

Television Projection Systems for Color Film Demonstrated

Three methods for telecasting film in color were demonstrated recently to broadcast engineering consultants at a color television seminar sponsored by the RCA Victor Division, Radio Corporation of America.

Significant among the new projection equipment under development was a system which utilizes three RCA vidicon tubes, which, by employing dichroic mirrors, can pick up and reproduce color film projected by standard black-and-white 16-millimeter film projectors.

In addition to the vidicon system, RCA also disclosed another method, now in commercial production, which utilizes a special 16-millimeter fast pulldown projector with a flying spot scanner. The third system, which, like the 3-vidicon system, is still under development, is a continuous film projector for 35-millimeter film which also is used in conjunction with a flying spot scanner.

It was explained that the differences in the two systems are in mechanical and electronic principles utilized. In one system, he said, the mechanical requirements are relatively simple while complex electronic developments are required. The other method, which utilizes the flying spot scanner, is electronically simple but requires complicated mechanical equipment. It was pointed out that the vidicon system will require precise color registration as well as three tubes with well-matched characteristics to function properly.

The third color projection system utilized a 35-millimeter continuous projector which along with recent developments by Bell Telephone Laboratory engineers makes it appear that it will be possible to eliminate heretofore objectionable vertical motion and also image flicker due to light variations in this system. The projector then can be successfully used with the flying spot scanner for color film projection.

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

TELEVISION FUNDAMENTALS. Theory, Circuits, and Servicing. By Kenneth Fowler and Harold B. Lippert. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N.Y., 1953. 524 pages, $9\frac{1}{4}$ by $6\frac{1}{4}$ inches, bound. $7. A manual for radio technicians, which describes the elements of a modern television receiving system, from antenna to picture tube, in line with the serviceman's needs. Basic electronic principles and complex circuits are described simply and clearly with a minimum of mathematics and engineering analysis. The book includes practical installation procedures, and devotes a chapter to the correction of circuit defects by picture analysis.

ULTRA HIGH FREQUENCY PROPAGATION. By Henry R. Reed and Carl M. Russell. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953. 562 pages, $9\frac{1}{4}$ by $6\frac{1}{4}$ inches, bound. $9.50. A study of current information on ultrahigh-frequency radio-wave propagation and its relation to the performance of the installation as a whole. Much of the material is devoted to an examination of dynamic system performance characteristics by a variation of the other elements and parameters of the system. This book provides a practical engineering understanding of such critical factors as reflection, refraction, diffraction, turbulence, directivity, and divergence, and points the way to ideal installation practices and effective maintenance.

HIGHER TRANSCENDENTAL FUNCTIONS, VOLUME I. Compiled by the Bateman Manuscript Project at the California Institute of Technology. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N.Y., 1953. 302 pages, $9\frac{1}{4}$ by $6\frac{1}{4}$ inches, bound. $6.50. An account of the principal properties of several classes of important special functions: the gamma function; the hypergeometric function; Legendre functions; the generalized hypergeometric series, and other generalizations of the hypergeometric function; the confluent hypergeometric function. These extensive and detailed treatments are the work of four outstanding mathematical analysts, and the work is to be carried on in several subsequent volumes.

PROBABILITY TABLES FOR THE ANALYSIS OF EXTREME-VALUE DATA. (Applied Mathematics Series 22.) National Bureau of Standards. Available from Superintendent of Documents, United States Government Printing Office, Washington 25, D. C., 1953. 32 pages, $10\frac{1}{4}$ by $7\frac{3}{4}$ inches, paper. $0.25. These specialized tables find use in the statistical approach to such practical engineering problems as the study of floods and droughts and the fracture testing of metals and other materials. The explanatory introduction discusses such applications as well as the general method of use of the tables, the method of interpolation, and so forth.

DIAMOND TECHNOLOGY. By Paul Grodzinski. N.A.G. Press, Ltd., London, England, second edition, 1953. 784 pages, $8\frac{1}{2}$ by $5\frac{3}{4}$ inches, bound. 52s. 6d. A comprehensive treatise on the methods and machinery used in working diamonds and other gems and hard materials. Part I covers machining methods, splitting, grinding and polishing, drilling, carving, and the production and use of diamond powder. Part II deals with the manufacture of instrument jewels and diamond and sintered-carbide dies, the selection and setting of industrial diamonds, the grinding of sintered carbides, and the production of piezoelectric and optical crystals.

SYMPOSIUM ON CONDITIONING AND WEATHERING. (Special Technical Publication, number 133.) American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1953. 98 pages, 9 by 6 inches, paper. $2.25. A wide range of topics is covered to provide a broad picture for technologists in many lines: the fundamentals of atmospheric elements; air conditioning in the manufacture and testing of textiles; conditioning and weathering of paper, adhesives, plastics, and organic and metallic coatings; outdoor exposure testing; and accelerated weathering devices.

ALTERNATING CURRENT ELECTRICAL ENGINEERING. By Philip Kemp. Macmillan and Company Ltd., London, England (available in United States from St. Martin's Press, 103 Park Avenue, New York 17, N. Y.) eighth edition, 1953. 680 pages, $8^{3}/_{4}$ by $6^{1}/_{4}$ inches, bound. $7.50. This new edition of a standard work presents the latest ideas and practices generally accepted in this field of study, at the same time maintaining the plan of the original work in adhering to principles and processes rather than describing particular types of apparatus. The material covered is carefully restricted to the main ground indicated in the title and in this connection electronics, for the most part, is not included. The British Standards Institution symbols, notations, and definitions are used.

AUTOMATIC CONTROL OF HEATING AND AIR CONDITIONING. By John E. Haines. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1953. 370 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $6.75. An introductory textbook which aims to explain and illustrate the basic problems of automatic control in the heating and air-conditioning field and the principles applied in solving those problems. The detailed treatment covers control fundamentals, electric- and pneumatic-control circuits, electric- and pneumatic-control units, and control equipment for domestic and commercial heating, unit heaters and ventilators, central-fan heating and cooling systems, commercial refrigeration, and radiant-panel heating.

MODULATION THEORY. By Harold S. Black. D. Van Nostrand and Company, Inc., 250 Fourth Avenue, New York 3, N. Y., 1953. 363 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $8.75. The first half of this text is concerned with the pertinent general philosophy of modulation theory, providing a framework for comparison of systems by such factors as the rate of receiving information, redundancy, bandwidth occupancy, threshold effects, signal-to-noise ratio, and so forth. The last half gives theoretical treatments of particular modulation systems on a unified base resulting from modern information theory.

THE PERFORMANCE AND DESIGN OF ALTERNATING CURRENT MACHINES. By M. G. Say. Sir Isaac Pitman and Sons, Ltd., London, England (available in United States from British Book Center, 122 East 55th Street, New York 22, N. Y.), second edition, 1952. 636 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $6.75. This textbook deals with the three principal types of a-c machines: the transformer, the 3-phase induction motor, and the synchronous motor and generator. The simple theory of each type is outlined, followed by discussion of modifications more in line with actuality and details of performance, control, testing, construction, and design. Design is not treated from the viewpoint of the commercial designer, but in accordance with the needs of students of heavy electrical engineering in general.

APPLICATION DE LA NOTION D'ECHAUFFEMENT RELATIF A L'ETUDE DE LA CONVECTION FORCEE DE LA CHALEUR. By Edouard Roche. France, Ministere de l'Air, Publications Scientifiques et Techniques, Number 267, Paris, France, 1952. 77 pages, $10^{5}/_{8}$ by 7 inches, paper. Ffrs. 750. An application of the theoretical aspects of heat transfer to the study of forced convection under various conditions. Formulas and graphs are developed and applied, and tables of the required physical constants of various gases and liquids are provided.

BIBLIOGRAPHY ON INDUSTRIAL RADIOLOGY, 1950–1952. (Fourth Supplement to Industrial Radiology.) By Herbert R. Isenburger. St. John X-Ray Laboratory, Califon, N. J., 1953. 18 pages, 11 by $8^{1}/_{2}$ inches, paper. $2. Approximately 500 additional references are contained in this continuation of a series which now runs to over 3,000 entries. The scope is broad, and a wide range of magazines, both domestic and foreign, is covered. The arrangement is chronological, with no author or subject index.

CONSTANTES THERMODYNAMIQUES DES GAZ AUX TEMPERATURES ELEVEES. By M. G. Ribaud. France, Ministere de l'Air, Publications Scientifiques et Techniques, Number 266, Paris, France, 1952. 169 pages, $10^{5}/_{8}$ by 7 inches, paper. Ffrs. 1,500. A discussion of the thermodynamic constants of gases at high temperatures, covering both the theoretical and practical aspects, including corrections to be applied in converting from the "perfect gas" state to actual gases. Numerical values are presented in tabular form for some 50 gases—simple elements, inorganic compounds, various hydrocarbons, and some monatomic forms.

MODERN PLASTICS ENCYCLOPEDIA AND ENGINEER'S HANDBOOK, 1953. Plastics Catalogue Corporation, 575 Madison Avenue, New York 22, N. Y., 17th edition, 1953. 943 pages, $11^{1}/_{2}$ by $8^{1}/_{2}$ inches, bound. Available to subscribers to *Modern Plastics* magazine. As in the previous editions, this useful reference work presents in detail recent developments in plastics engineering and methods, machinery, and equipment, and plastics materials. A major section is now devoted to film and sheeting, and also to laminates and reinforced plastics. The Technical Data section includes the large, folded plastics properties chart, and the Directory section provides buyers' guides and a list of trade names.

OPPORTUNITIES IN ELECTRICAL ENGINEERING. By S. Paul Shackelton. Vocational Guidance Manuals, 45 West 45th Street, New York 36, N. Y., 1953. 128 pages, $7^{7}/_{8}$ by $5^{3}/_{8}$ inches, paper. $1. This manual, designed to aid young people in the selection of a career, defines the scope and describes the field of electrical engineering, and discusses qualifications, educational requirements, licensing, getting a job, advancement, opportunities for employment, and opportunities in related fields such as manufacturing, sales, and law. The Engineers' Council for Professional Development list of "accredited undergraduate engineering curricula" is appended.

POWER PLANT ENGINEERING. By Frederick T. Morse. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y., third edition, 1953. 687 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $8.75. Although extensively revised, this text retains the same objective: the presentation of a thorough study of stationary power and heating plants, including public service, industrial, and institutional varieties. Fundamentals are given primary consideration, omitting details and dimensions of equipment, and the power plant is emphasized as an integrated assembly with more space devoted to the small plant than before. Load problems, economics, and instrumentation are dealt with.

REGULATION HYDRAULIQUE D'ALIMENTATION DES TURBOMACHINES. By Basile Demtchenko. France, Ministere de l'Air, Publications Scientifiques et Techniques, Number 277, Paris, France, 1953. 182 pages, $10^{3}/_{4}$ by 7 inches, paper. Ffrs. 1,500. A detailed presentation of schematic and mathematical analyses of hydraulic control methods of combustion-gas flow in turbomachines with particular reference to gas turbines and jet propulsion for airplanes. Part I contains the theoretical treatment; Part II describes applications, including the operation of existing types.

A SIMPLE GUIDE TO MODERN VALENCY THEORY. By G. I. Brown. Longmans, Green and Company, 55 Fifth Avenue, New York 3, N. Y., 1953. 174 pages, $8^{1}/_{2}$ by 5 inches, bound. $2.50. In this concise, general account an outline of the structure of atoms, in which particular attention is paid to the arrangement of extra-nuclear electrons, leads to a detailed consideration of extravalent, covalent, and dative bonds. A short account of experimental methods and results and simple treatments of resonance, the hydrogen bond, and the method of molecular orbitals also are given.

TABLES OF NORMAL PROBABILITY FUNCTIONS. (Applied Mathematics Series, Number 23.) National Bureau of Standards. Available from Superintendent of Documents, General Post Office, Washington 25, D. C. (a reissue of Mathematical Table *14*, with corrections) 1953. 344 pages, $10^{1}/_{2}$ by 8 inches, bound. $2.75. A companion volume to the previously published tables of the error function and its derivative, this book presents a tabulation of the functions $Q(x)$ and $P(x)$ to 15 decimal places at intervals of 0.0001 in the range of x between 0 and 1, and of 0.001 for x between 1 and 7.8. An explanatory introduction and a bibliography are included.

TIMING ENGINEERING. By Myrten G. Saake. Ribble Engineering Company, 74–80 Montgomery Street, Jersey City 2, N. J., first edition, 1953. 243 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $5. This first full-length reference book on industrial timers covers basic design, construction, and application in relation to automation of machinery and processes. Single- and multiple-circuit program timers and single- and multiple-circuit automatic reset timers are described in detail with circuit diagrams. Synchronous-motor-driven timers are mainly considered but brief mention is made of electronic, pneumatic, and thermal timers. A separate chapter deals with automatic counters.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Electronic Components. The proceedings of the Electronic Components Symposium held April 29–May 1, 1953, have been published. The complete text of some 30 papers by recognized authorities in the electronics industry is contained in the proceedings. The general sessions under which papers were presented and have been published are General Component Problems, Environment and Packaging, Tubes and Tube Reliability, Component Reliability, Resistors, Capacitors and Dielectrics, and Devices and Materials. $4.50. Available from Los Angeles Division of Stanford Research Institute, Suite 1011, 621 South Hope Street, Los Angeles 17, Calif.

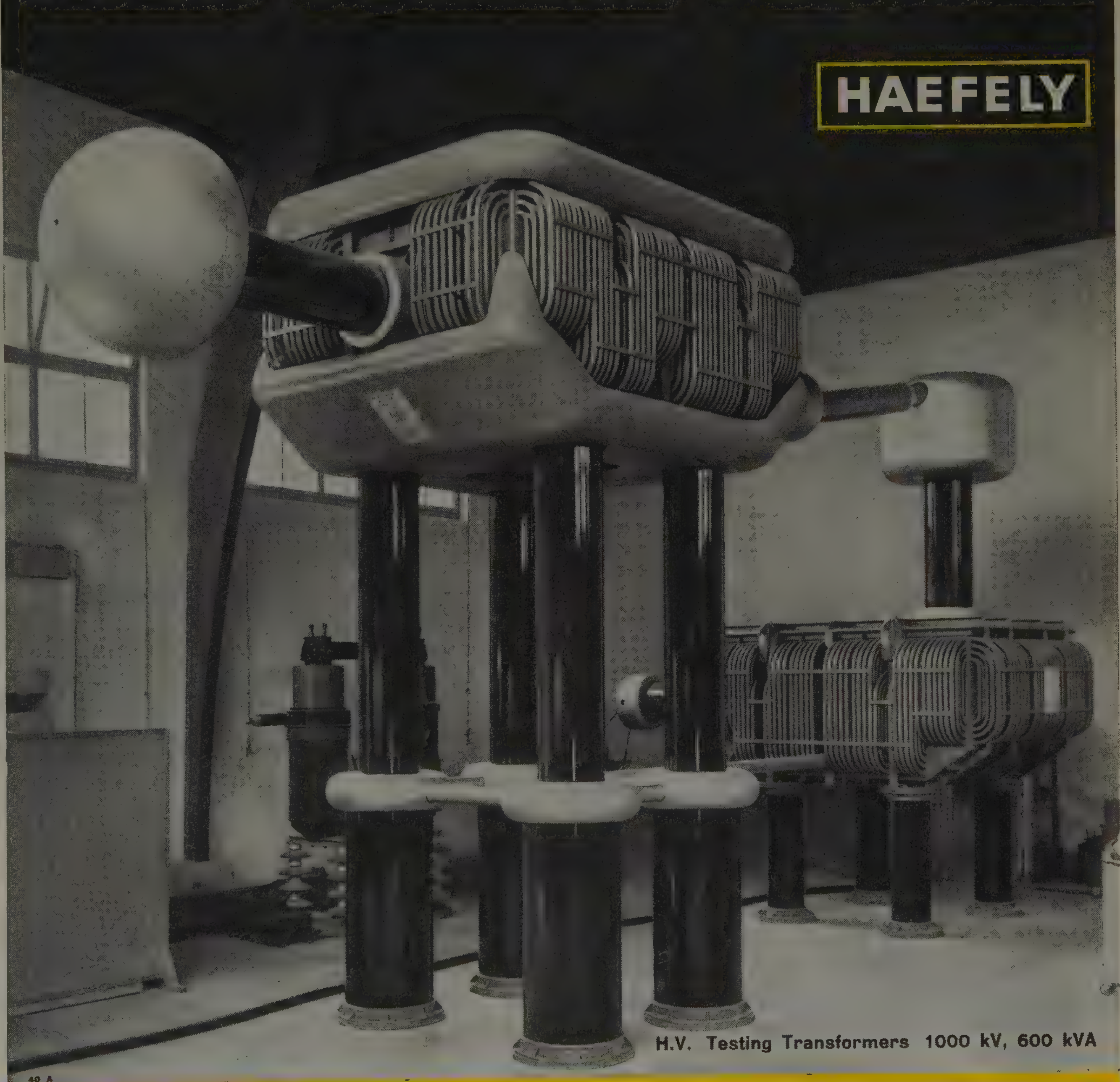
Engineering Formulas and Tables. Newly revised, this pocket-size data book includes basic formulas, design data, and tables. Sections include mathematics, measures, materials, gauges, screws, mechanics, electricity and magnetism, hydraulics, structural data, reinforced concrete, pipe and fittings, steam tables, and mathematical tables. 350 pages. $2.75. Order from Lefax Publishers, Philadelphia, Pa.

Fuse Specifications. The International Electrotechnical Commission has published a Specification for Fuses for Voltages Not Exceeding 1,000 Volts for Alternating and Direct Currents. The publication fixes the characteristics necessary in specifying the conditions of design and operation of fuses. The Commission also has named in the booklet: requirements relating to breaking capacity, time-current zone, cutoff characteristic, temperature rise, insulating characteristics, watts loss in fuse links, and protection against contact with live parts. Tests which must be met to insure the compliance of fuses with the requirements, together with the methods for making tests, also are specified. The publication contains internationally agreed upon definitions pertaining to fuses and a special section of markings on fuse links, fuse bases, and fuse carriers. 49 pages. $1.75. Available from the American Standards Association, 70 East 45th Street, New York 17, N. Y.

Frequency Spectra and Fault Transients of a D-C Generator. This report of experiments carried out by the Naval Research Laboratory with a d-c generator points out that the eddy currents which have an appreciable effect on generator operations can be treated mathematically and the fault-current transients calculated. The methods used in this work are so general that engineering technicians and generator builders may use them readily in any system having a d-c generator as a component. 24 pages. 75¢. Available from the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

HIGH VOLTAGE TESTING

HAEFELY



H.V. Testing Transformers 1000 kV, 600 kVA

Testing Transformers - Impulse Generators H.V. Rectifiers - Potentiometers for a.c., d.c. and Impulse-Voltages - Cathode-Ray Oscillographs

Designed individually and adapted to special requirements

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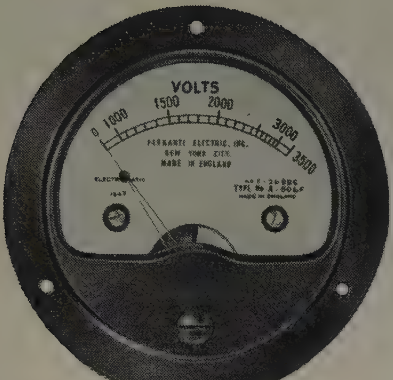

This instrument permits voltage readings on AC or DC circuits of very high resistance. The only current drawn is the very small leakage current and a very low capacitance current on AC circuits. Very useful for the many high voltage—low current circuits employed in nuclear research. Available with full scale voltages ranging between 300 and 3500 volts. Special laboratory instrument available with full scale reading of 150 volts. Full scale capacitance ranges from 8 mmfds for the 3500 volt model to 100 mmfds for the 150 volt instrument. Magnetic damping. 2½" dial. Write for complete specifications.

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FERRANTI, LTD., Hollinwood, England
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INDUSTRIAL NOTES ....

Westinghouse Notes. Marcus N. Brooks has been appointed purchasing agent for the Television-Radio Division, Metuchen, N. J. He will have his offices at the division's new headquarters plant located in nearby Raritan Township, where television sets are assembled.

Robert H. Wagner has been appointed general application engineering manager of the Westinghouse Elevator Division in Jersey City, N. J. In his new post, he succeeds Edward B. Dawson, who recently was named division engineering manager.

General Electric News. General Electric's Tube Department climaxed its biggest year of warehouse growth with a formal dedication of its new 25,000-square-foot western regional warehouse at 11840 Olympic Boulevard, Los Angeles, Calif. The new facility will house General Electric's western tube sales offices, an extensive commercial engineering laboratory, and commercial service offices, in addition to the tube processing and storage areas. The warehouse will serve California, Oregon, Washington, Idaho, Nevada, Arizona, Utah, and parts of Montana and Wyoming.

The Electronics Division, Syracuse, N. Y., has announced the establishment of a commercial equipment department to concentrate the division's efforts in such areas as monochrome and color television station equipments, industrial radio and microwave communications, and germanium products. William J. Morlock has been appointed manager of the new department.

Two appointments in the appliance control department, Schenectady, N. Y., have been announced. B. R. Elam, Jr., will be in charge of promotional activities for the department's full line of controls for appliance and home heating industries. Robert F. Dee was appointed market research specialist with duties related to the study of industry trends, market possibilities for new products, and short-term forecasting.

The appointment of Aaron M. Krakower as manager of electronic and high-voltage transformer sales for the newly formed specialty transformer department, Schenectady, was announced.

Three key appointments in the communication equipment department in the Electronics Division at Syracuse, have been announced. Lacy W. Goostree, Jr., was appointed manager of marketing, Charles M. Heiden was named manager of engineering, and Clair C. Lasher was appointed manager of manufacturing.

Increased manufacturing facilities at the receiving tube plant at Tell City, Ind., will be housed in a newly completed 44,000-square-foot plant addition. All component parts and mounts for receiving tubes will be processed in the new addition, for processing into completed tubes in the plant.

Three appointments in the germanium products unit of the commercial equipment department have been announced. James H. Sweeney has been named manager of marketing. James E. Keister was appointed manager of engineering and Theodore E. Jamro was named manager of manufacturing. Mr. Sweeney and Mr. Keister will make their headquarters at Electronics Park in Syracuse, while Mr. Jamro will have his headquarters at the company's germanium products plant at Clyde, N. Y.

Vincent P. Gregg has been appointed product planner for the company's specialty motor department in Schenectady. Mr. Gregg's duties will include the integrating, planning, and timing for various product lines and programs.

Du Mont Appointment. William H. Kelley was named vice-president in charge of marketing of Allen B. Du Mont Laboratories, Inc. Mr. Kelley is widely known in the radio and television trade as one of the nation's most successful sales and merchandising executives.

Raytheon Promotion. Gordon S. Humphrey, executive assistant to the general manager of Raytheon Manufacturing Company's equipment division, has been appointed an assistant vice-president of the company. Mr. Humphrey, who has been with Raytheon for 10 years, joined the company during the early years of World War II to handle its government contract negotiations and to organize and develop a government contract department.

Du Mont Service Representative. The addition of Pinkney and Hine of Minneapolis, Minn., as service and repair representatives for Du Mont Oscillographs makes a total of 13 authorized service centers. Pinkney and Hine, 522 Plymouth Building, Minneapolis, Minn., are selling agents for technical products of Allen B. Du Mont Laboratories, Inc., and now have been authorized to service and repair Du Mont cathode-ray oscillographs and accessories.

New Association. Official organization of the Magnetic Recording Industry Association was announced recently by the organization's newly elected president, Joseph R. Hards, vice-president of A-V Tape Libraries, New York, N. Y. Nineteen members of the new trade association of magnetic recording equipment and media manufacturers met to vote on the constitution and bylaws of the group and to elect its officers and board members.

IT&T Appointments. The appointment of Brigadier General Peter C. Sandretto, United States Air Force Reserve, as technical director of the Federal Telecommunication Laboratories, Nutley, N. J., a division of International Telephone and Telegraph Corporation, has been announced. He was formerly assistant technical director. General Sandretto joined the corporation in 1946 and has served since in key executive positions in the field of aero-

(*Continued on page 22A*)

Guard against this nightmare

Wind and ice loading are kept at a minimum by Rome self-supporting cables. They reduce crossarms and permit shorter poles.

Fewer accessories, reduced cable cost and cleaner, neater installations result from using Rome Triplex service drop cable.

Poles top-heavy with crossarms and wires. A viscious ice storm. Heavy winds. Broken poles and wires. It is the nightmare of power outage and costly replacements.

You can minimize this expense and customer dissatisfaction by standardizing on Rome self-supporting cables.

Manufactured to your specification, with either copper or aluminum conductors, Rome self-supporting cables utilize the time-proven construction of insulated power conductors spiralled around, or bound to a neutral or supporting messenger. These cables are mechanically predesigned, with a large factor of safety, to anticipate ice and wind loading.

Low installation and maintenance costs

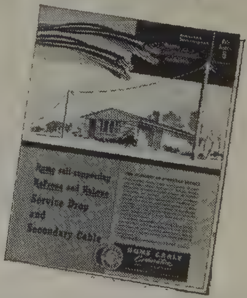
You will realize substantial savings with Rome self-supporting cables, both in installation and maintenance. Crossarms can be eliminated, less hardware is required and, often, fewer poles because of longer spans. Maintenance costs are lower, too. Requiring no common covering, conductors are readily accessible for easy taps. Tree trimming is minimized through excellent resistance to abrasion.

Longer service life in all weather

Insulated or sheathed with RoLene (polyethylene) or RoPrene (Neoprene), Rome self-supporting cables are unaffected by sunlight, moisture and corrosive atmospheres. There are no fibrous braids to rot and festoon. Replacement is kept to a minimum. Better voltage regulation is, also, a factor because of lower reactance due to the close spacing of insulated conductors in long or heavily loaded circuits.

Whether for 600 volts or 15,000 volts, if it is going overhead, it will pay to do as so many others are doing . . . check the advantages and economies of Rome self-supporting cables. They are cables engineered to the service involved. The coupon below will bring you information on their properties and characteristics.

You'll find a wealth of helpful information on physical and electrical characteristics, specifications, dimensions and installation data on these and other Rome wires and cables in Bulletin RS-5, and the Power and Control Cable Catalog. Send for them today. Mail the coupon.



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ROME CABLE CORPORATION, Dept. EE-12, Rome, N. Y.
Please send copy of .... Bulletin RS-5; .... Rome Power and Control Cable Catalog.

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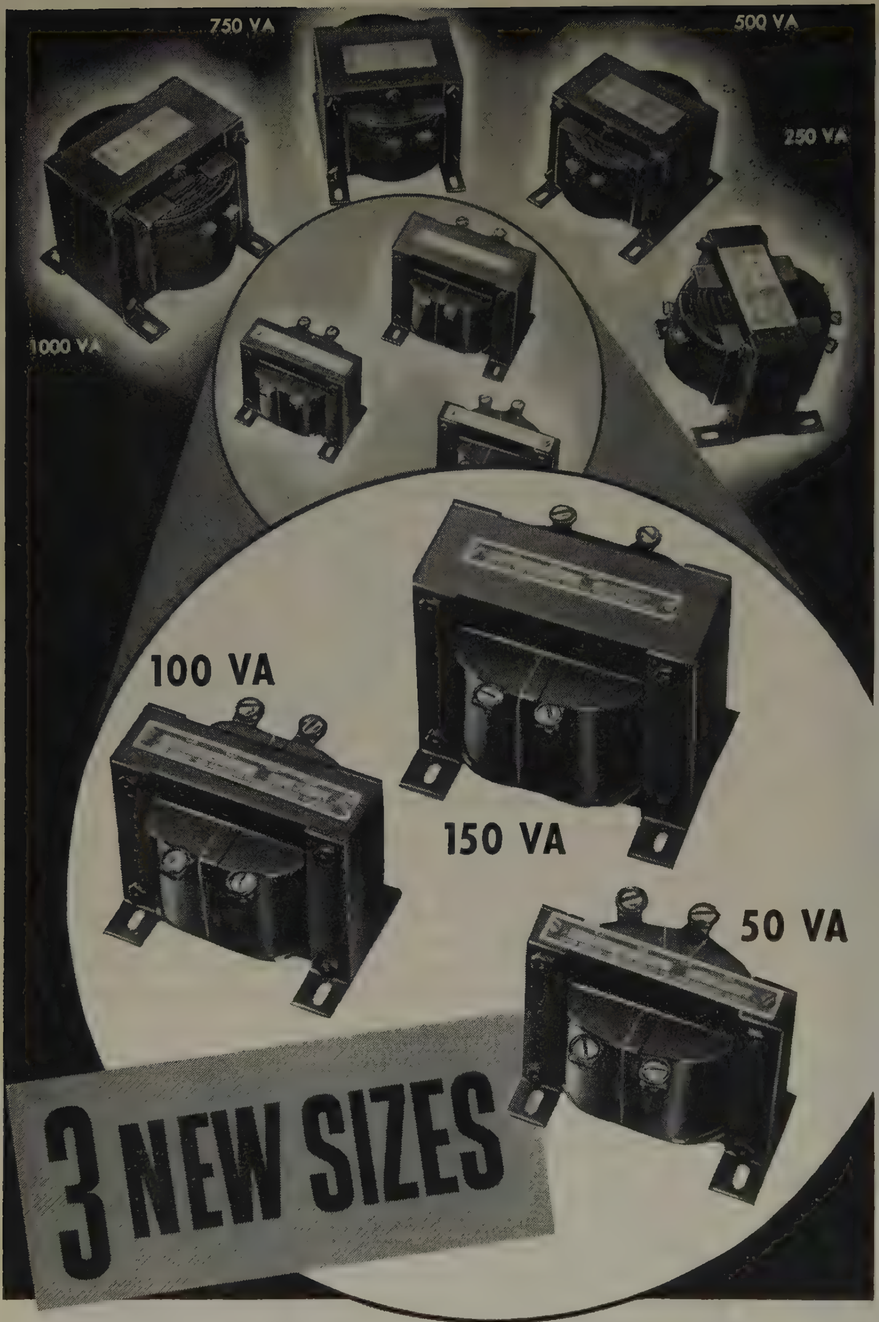
Company..

Address..

City.. Zone........ State...........



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CONTROL CIRCUIT TRANSFORMERS

Now available in smaller transformers is the same high standard of construction and electrical characteristics proved so successful by our larger sizes. Designed specifically to handle high inrush currents encountered in industrial machine control, these transformers provide better regulation of circuit voltage. Specify Hevi Duty Transformers to assure yourself of dependable service. Available in sizes from 50 V.A. through 10,000 V.A. Write for Bulletin T-5111.

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Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers *Constant Current Regulators*

(Continued from page 18A)

nautical radio engineering. Henry G. Busignies, former technical director, has been appointed a vice-president and member of the Management Advisory Board.

Henry C. Rowmer, president of Federal Telephone and Radio Company, has been designated as vice-president in charge of the administration of the Domestic Divisions of the International Telephone and Telegraph Corporation. These divisions are Federal Telephone and Radio Company, Clifton, N. J.; Federal Telecommunication Laboratories, Nutley, N. J.; Kellogg Switchboard and Supply Company, Chicago, Ill.; Coolerator Company, Duluth, Minn.; and Capehart-Farnsworth Company, Fort Wayne, Ind.

Raymond S. Perry has been elected president succeeding Mr. Rowmer. In assuming the presidency of Federal, Mr. Perry brings to that post wide experience in the fields of electronics and communications.

The appointment of J. A. Frabutt as general sales manager was announced. Mr. Frabutt fills the vacancy on the administrative staff created by the recent designation of Mr. Perry.

New Manager. The appointment of Dr. O. G. Haywood, Jr., as manager of engineering planning of Sylvania Electric Products, Inc., was announced. In his new position, Dr. Haywood will co-ordinate, in co-operation with executives of the operating divisions and research laboratories, Sylvania's engineering planning in fields of lighting, radio, electronics, and television.

Philco Changes. Philco International Corporation has announced the transfer of its sales and advertising departments to Philadelphia, Pa., from New York City. The company maintains export warehouses in Philadelphia, New York City, and Middletown, N. Y., as intermediary points for storage of Philco products intended for shipment to practically every country in the world outside the iron curtain.

James J. Shallow, sales manager, Philco Distributors, Inc., of Philadelphia, has been appointed general manager of the Accessory Division of Philco Corporation.

Completion of Palermo Power Plant. Construction of the Palermo Steam Power Plant in Sicily, Italy, has been completed. Designed and engineered by The Kuljian Corporation, the new Palermo station was financed by the Economic Co-operation Administration program of the United States and is located in the city of Palermo, Sicily, adjacent to the Mediterranean Sea. It is owned by a public utility, "Societa Termo-Elattrica Siciliana." The Palermo plant consists of 30,000-kw units plus outside fuel-handling facilities, intake and discharge channels. The Economic Co-operation Administration Citation Award was presented to The Kuljian Corporation for outstanding performance on this project, one of the few presented to an engineering

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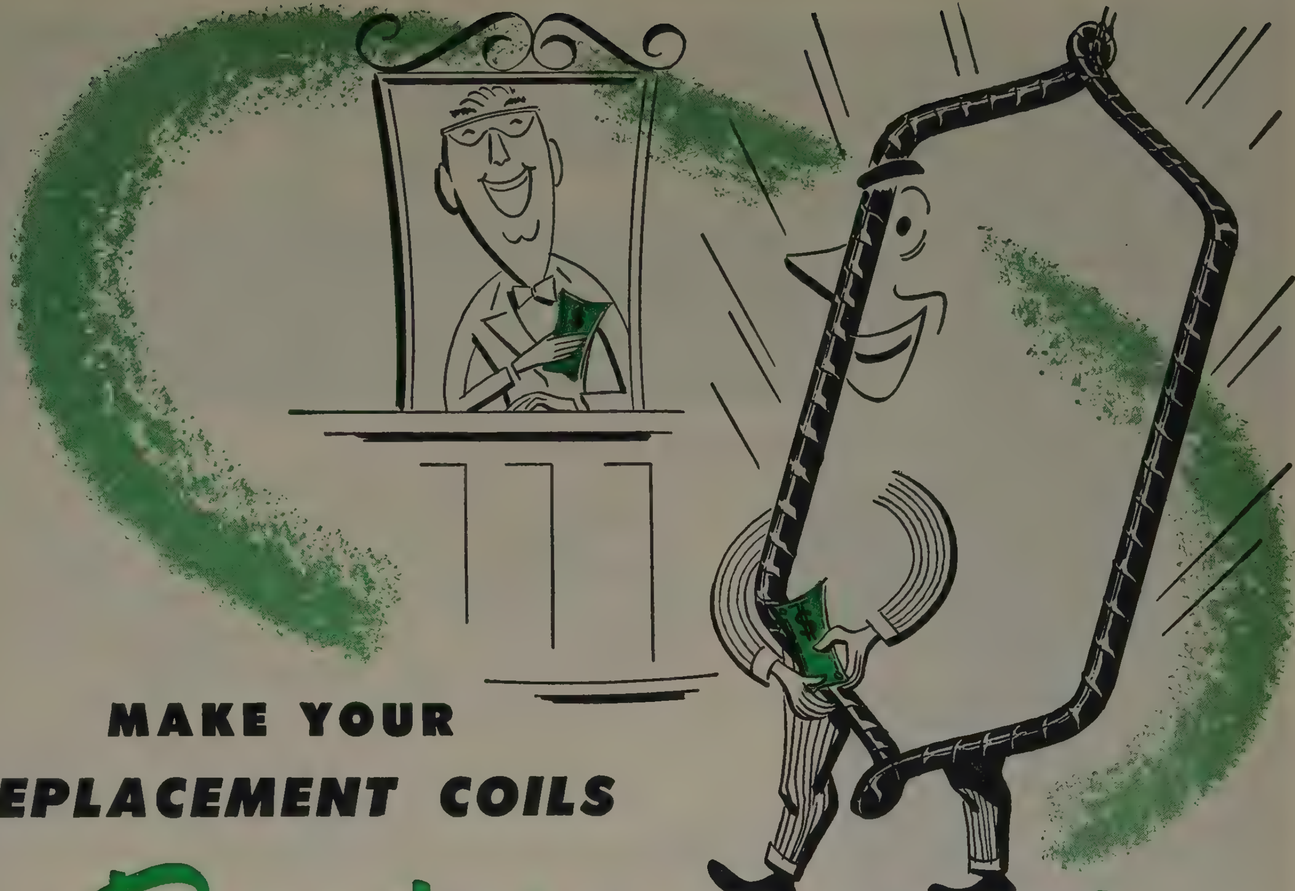


MAKE YOUR REPLACEMENT COILS

Pay their own way!

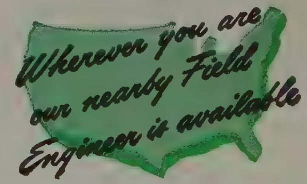
An electro-metalurgical producer is drawing a large annual power bonus because National maximum-capacity design boosted the capacity of his generator by 15.9 per cent. Increased output will pay for the complete rewinding job in a little more than two years.*

"As good as new" is *not* good enough for National. A generator or motor with National replacement windings *must be better than new.* Every phase of National engineering and production is directed toward this objective.

Redesign for maximum capacity is typical of extras you can count on from National. Where increased output can be used or sold, National replacement windings will pay for themselves over a very short period of time. Where it cannot be utilized, extra capacity reduces operating temperatures and results in substantially longer coil life.

If you operate heavy rotating electrical equipment for any purpose, you can operate it more profitably with National windings. Get in touch with your nearby National field engineer today. Find out how National maximum-capacity design and National extra-quality coils can help your motors and generators do a better job.

*Complete details on this installation available on request.



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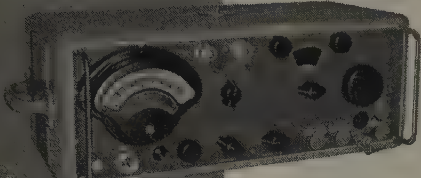
ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

STANDARD

Radio Interference and Field Intensity

MEASURING EQUIPMENT

Complete Frequency Coverage—14kc to 1000 mc!



NM-10A

VLF

14kc to 250kc
Commercial Equivalent of AN/URM-6B.
Very low frequencies.

NM-20B

HF

150kc to 25mc
Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies.

NMA-5A

VHF

15mc to 400mc
Commercial Equivalent of TS-587/U.
Frequency range includes FM and TV Bands.

NM-50A

UHF

375mc to 1000mc
Commercial Equivalent of AN/URM-17.
Frequency range includes Citizens Band and UHF color TV Band.

These instruments comply with test equipment requirements of such radio interference specifications as MIL-I-6181, MIL-I-16910, PRO-MIL-STD-225, ASA C63.2, 16E4, AN-I-24a, AN-I-42, AN-I-27a, MIL-I-6722 and others.

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(*Continued from page 22A*)

firm in recognition of superior work done for peoples of other countries.

New Magnecord President. The election of William L. Dunn, former vice-president of the Television and Radio Division of Raytheon Manufacturing Company, as president of Magnecord, Inc., was announced by Glenn D. Roberts, retiring president of the Chicago tape recorder manufacturing company. Mr. Dunn resigned from Raytheon where he headed the sales and engineering departments.

Atomic Industrial Forum Changes. Charles E. Robbins, formerly vice-president of Bozell and Jacobs, Inc., has been appointed executive manager of the Atomic Industrial Forum, Inc. Oliver Townsend, formerly the assistant to the chairman of the Atomic Energy Commission, was named as assistant executive manager and secretary of the forum.

BullDog Names District Manager. BullDog Electric Products Company, Detroit, Mich., has appointed J. Donald Akers as district manager of its Detroit, Mich., sales office. He will direct the sales activities of the 8-man sales staff in the Detroit metropolitan area.

NEW PRODUCTS • •

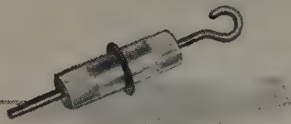
Mirror-Back Picture Tube. CBS-Hytron's mirror-back picture tube reinforces light output producing a brighter and sharper picture with greater contrast, reduced strain on component parts, full effective screen potential maintained by metallic contact between anode and screen, and longer life because of the reduction of cathode drain. Employment of a mirror-like principle virtually doubles the picture brilliance of the CBS-Hytron *24TP4/-24CP4A*, *27EP4*, and *27RP4* mirror-back tubes, without additional strain on component parts of big screen television sets using these tubes.

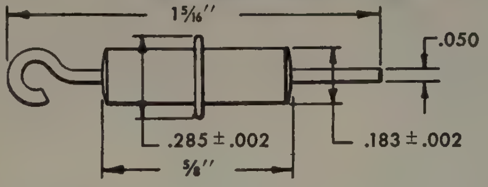
Inverter Control. Jack and Heintz, Inc., Cleveland, Ohio, has announced the manufacture of a new speed and voltage regulator assembly designated as the *FRS*. It will be incorporated on all Jack and Heintz 1,500- and 2,500-volt-ampere inverters. The *FRS* combines into one unit the functions formerly performed by two separate units, the speed governor and the voltage regulator. Both frequency and voltage regulation in the assembly employ carbon-pile amplifiers rated 45 watts. Additional information may be obtained from Jack and Heintz, Inc., 17600 Broadway Avenue, Cleveland 1, Ohio.

(*Continued on page 38A*)

NOW
Kel-F* hermetic sealing terminals

IRC's new FEED-THRU TERMINALS provide assured hermetic sealing for electrical and electronic components. Exclusive IRC molding technique bonds Kel-F* to metal in a superior and consistent hermetic seal. Type HS-1 terminals are designed to the sealing requirements of MIL-T-27. Send coupon for data bulletin.





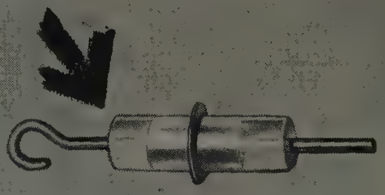
MATERIAL

Central Conductor	Phosphor Bronze
Body	*Kel-F (Trifluorochloroethylene polymer)
Flange	Brass
Finish	Natural or tin plated

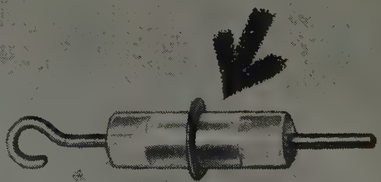
SPECIFICATIONS

Current Rating	15 amps.
Dielectric Strength	5000V (RMS) 60 cps
Corona Starting Voltage	over 2000V (RMS) 60 cps
Air Pressure Test	20 pounds/sq. in.
Terminal Pull Test	7 pounds
Torque Test	10 inch ounces applied to central conductor
Insulation Resistance	over 10,000,000 megohms
Maximum Continuous Operating Temperature	150°C.
Short Time or Intermittent Operating Temperature	200°C.

*Trademark—M. W. KELLOGG CO.



ELECTRICAL CHARACTERISTICS— limitations of other types of hermetic sealing terminals are all fully overcome.



MOLDED KEL-F* BODY— chemically inert to organic solvents, acids, oils, fumes.

RUGGED CONSTRUCTION— tough and resilient; withstands constant vibration.

IRC'S KEL-F* MOLDING TECHNIQUES ARE AVAILABLE FOR CUSTOM MOLDING. INQUIRIES ARE INVITED.

Voltmeter Multipliers • Boron & Deposited Carbon Precistors • Insulated Composition Resistors • Power Resistors • Volume Controls • Low Wattage Wire Wounds •

Wherever the Circuit Says—

IRC

Precision Wire Wounds • Ultra HF and Hi-Voltage Resistors • Low Value Capacitors • Selenium Rectifiers • Insulated Chokes • Hermetic Sealing Terminals •

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Please send Technical Bulletin HS-1, describing hermetic sealing terminals:

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★ POWER RELAYS
★ SMALL RELAYS
★ SENSITIVE RELAYS
★ LATCH RELAYS
★ INSTRUMENT-CONTROLLED RELAYS and SETS
★ SEQUENCE RELAYS
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5,348 RELAY TYPES

...mean that you get exactly the right relay for the job!

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ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

(*Continued from page 28A*)

Power Resistor. Castohm, a radically new type of fixed wire-wound power resistor, has been developed by the Shallcross Manufacturing Company, Collingdale, Pa. Through a unique process, the windings of the new resistors are firmly imbedded in a special ceramic which forms an integral coating and core. Thus, by eliminating the usual heavy ceramic core, Castohm resistors have been made in smaller diameters and with almost 25 per cent less weight than conventional tab terminal power resistors of comparable wattage ratings. Engineering Bulletin *L-29*, which gives complete specifications, typical laboratory test results, and physical and mounting dimensions, is available on letterhead request to the manufacturer.

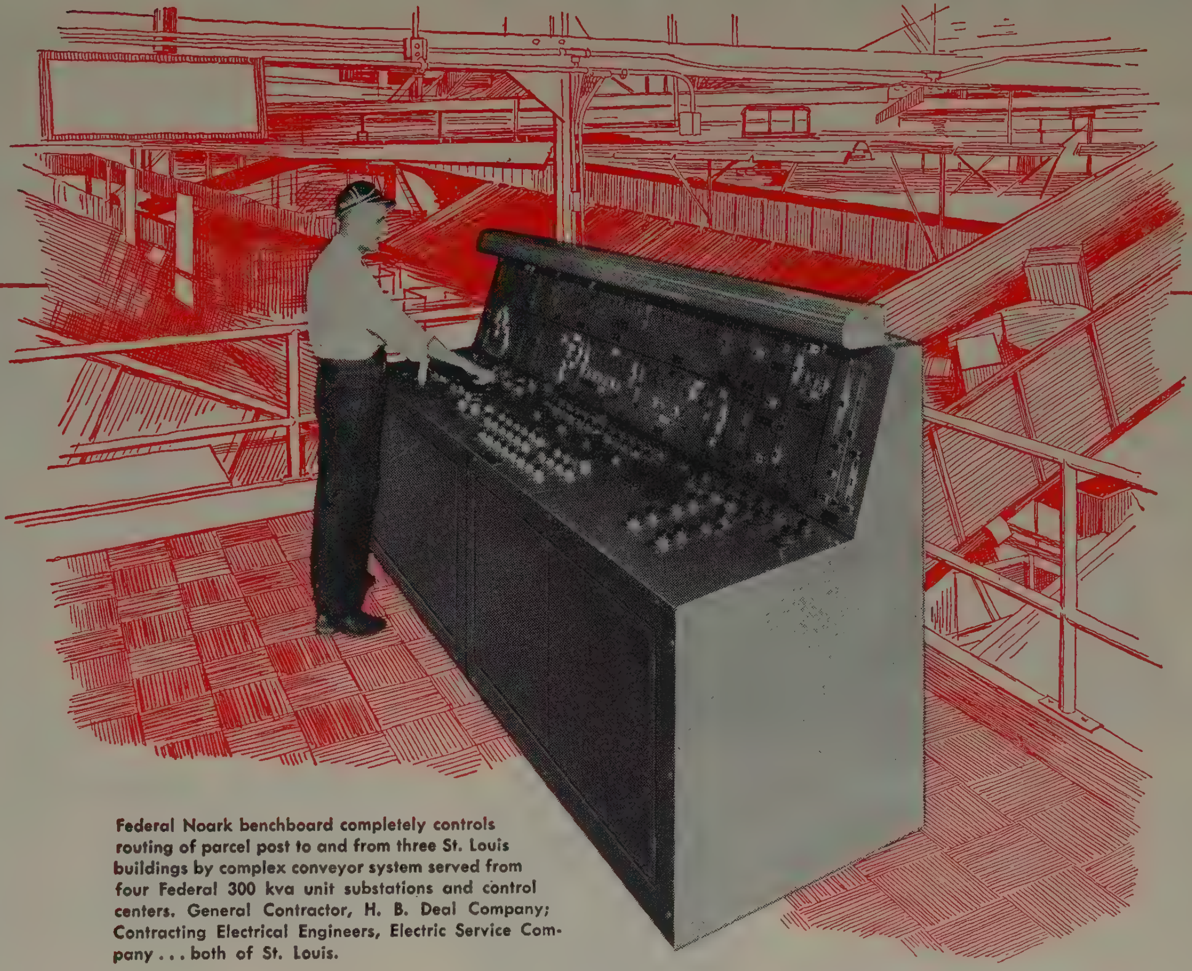
Vibration Relay. A new protective device, which initiates a signal when excessive vibration due to unbalance occurs in large rotating equipment, has been announced by the General Electric Company's Special Products Section. The vibration relay, specifically engineered for apparatus which is left unattended for long periods, can be used on such equipment as turbine or water-wheel generators, large motors, blowers, steam or gas turbines, and centrifuges. It has an operating range which allows its use at speeds from 300 to 18,000 rpm to energize warning-alarm, corrective, or shut-down devices at preset vibration of acceleration values up to 20 accelerations of gravity. Design features permit easy calibration in the field and safe installation where dust conditions exist.

Tape Recorder. The Magnecorder *M80*, designed for $10^1/_2$-inch reels and incorporating all the latest features of advanced design and precision engineering, has been introduced by Magnecord, Inc. Among its features are slot loading, unitized construction, and full-range frequency response from 30 to 15,000 cycles per second at $7^1/_2$-inches-per-second tape speed. Other features include an automatic tape lifter which raises the tape from the heads during rewind and high-speed forward operations, push-button controls, and positive timing, assured through direct tape drive in conjunction with electric supply and take-up torques. Both playback and record amplifiers use direct-coupled cascade input stages which produce maximum signal-to-noise ratio. The unit also features 2-speed operations with dual equalization, detachable snap-on head covers, 4-channel mixer, facilities for remote control operation, and interchangeable head assemblies permitting full-track, half-track, or instrumentation recording.

Monitran. The Monitran, a low-powered radio-frequency television transmitter designed to meet broadcasting station monitoring needs, is now available from the Broadcast Equipment Section of the Engineering Products Department, it was

(*Continued on page 46A*)

NOW! FEDERAL NOARK®
HELPS SPEED ST. LOUIS MAIL



Federal Noark benchboard completely controls routing of parcel post to and from three St. Louis buildings by complex conveyor system served from four Federal 300 kva unit substations and control centers. General Contractor, H. B. Deal Company; Contracting Electrical Engineers, Electric Service Company . . . both of St. Louis.

PARCEL POST in St. Louis is now rapidly moved by the Terminal Railroad Association's new conveyor system from Union Station, a new Terminal building, and the Post Office. This system, the most elaborate of its kind in the country, is powered from four Federal Noark Unit Substations and controlled by a specially-designed Federal Noark indicating bench board.

The unit substations are 300 kva, 4180/480 volt, 3-phase. Each has a three-position fused primary selector switch so that either of two primary sources can be selected. Each station has a main secondary breaker feeding a close-coupled control center. Secondaries from all units can be tied together through Federal Noark Bus Duct.

The benchboard completely outlines the entire system and can select any number of conveyor arrangements which are instantly indicated by illuminated routings shown in miniature.

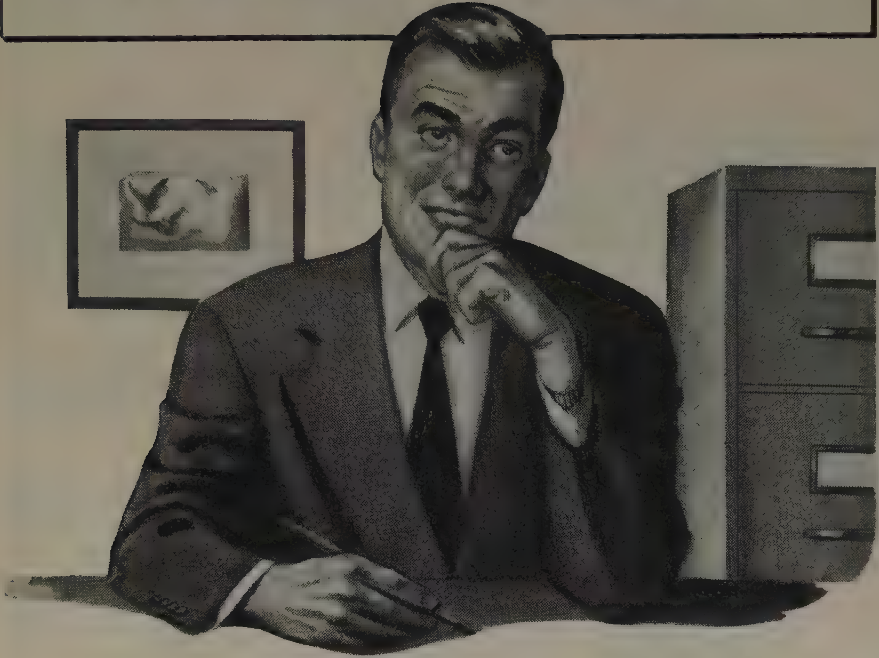
Here is another example of Federal's ability to handle your distribution or control problems. Remember, Federal Noark has the engineering skill and manufacturing facilities to provide exactly the right equipment for your requirements.

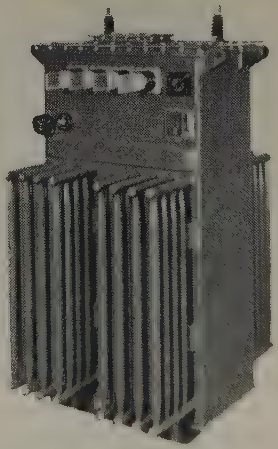
Federal Electric Products Company
50 Paris Street, Newark 5, New Jersey

Federal Noark products: Stab-lok Circuit Breakers, Motor Controls, Safety Switches, Service Equipment, Industrial Circuit Breakers, Panelboards, Switchboards, Control Centers, Bus Duct — **Pacific Electric Manufacturing Corporation products:** High voltage circuit breakers and power switches ★ Sales offices in principal cities.

FEDERAL NOARK®

"Why do so MANY people decide on
NIAGARA
TRANSFORMERS?"

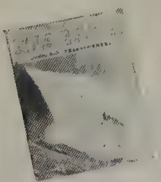




NIAGARA 500 KVA, 60 cycle, single phase, 2400/4160Y - 240 x 480 volt oil-immersed self-cooled transformer conforming to EEI-NEMA 5th report.

Is it the reputation for reliability that Erie has earned over the years? Is it the dependable way that every Niagara Transformer has performed? Is it the fact that delivery promises are commitments that we take seriously? Yes, these are all important reasons why people all over the world come back again and again for Niagara Transformers.

BUT . . . there's a hidden plus value that makes all this possible. It's the ATTITUDE of the people here at Erie Electric that actually build the transformers. These men grew up in the transformer business and their pride in their workmanship, we believe, is rare these days. They just *won't* let a shoddy piece of work slip by. That's a plus value that doesn't increase your price but it sure increases the reliability of your transformer. Make sure that Erie Electric quotes on *your* next transformer.



Send for this **FREE BOOK!**

Get acquainted with all the plus values in a Niagara Transformer. Write on your letterhead for this big, fully illustrated and informative book.

ERIE ELECTRIC CO., INC., 114 CHURCH ST., BUFFALO, N. Y.
OFFICES IN ALL PRINCIPAL CITIES
POWER • LIGHTING • LOAD CENTER • OIL-IMMERSED • DISTRIBUTION • UNIT SUBSTATION • DRY-AIR COOLED • NON-INFLAMMABLE

(*Continued from page 38A*)

announced by the RCA Victor Division, Radio Corporation of America. The Monitran develops both a picture and a sound carrier on any one of the very-high-frequency television channels, and requires but a single coaxial cable to feed its monitoring signal to one or more receivers at any point in the television studio. Several Monitran units can be used simultaneously on different channels to provide a selection of signals at television monitor receivers by tying their outputs together with an inexpensive resistor matching network and connecting the common radio-frequency output, in turn, to the station's coaxial feed line.

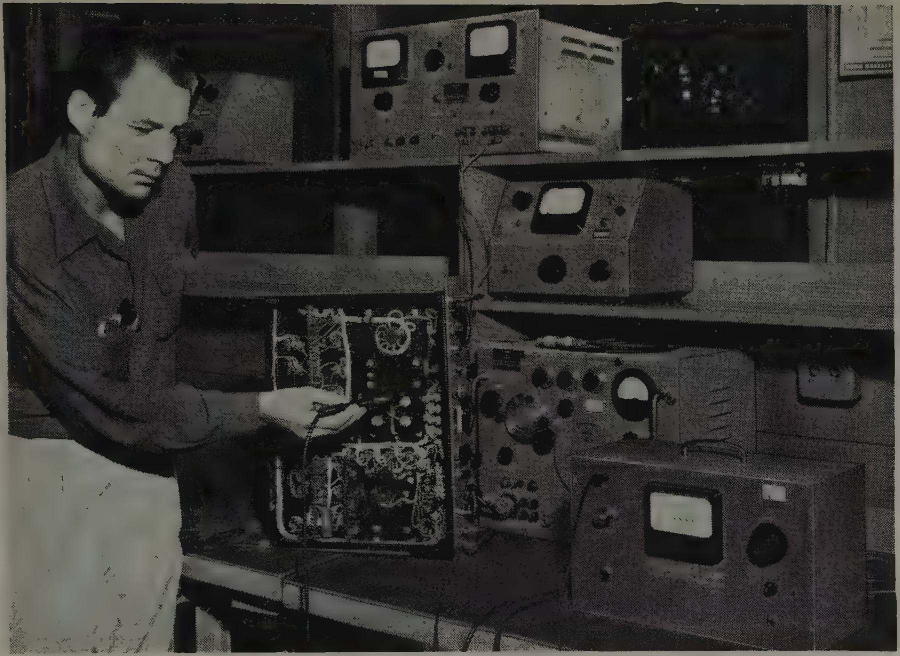
Two Residential Heat Pumps. A completely automatic heating and air-conditioning system that requires combustion and uses no water is now available from the Westinghouse Electric Corporation. Called the Type *HP* Heat Pump, the new system keeps the home at the proper temperature for maximum comfort throughout the year. It provides heat in the winter, cooling and dehumidification in the summer, and ventilation, circulation, and continuous cleaning of the air. The all-electric unit depends solely on air for its exchange medium. In summer it draws heat from inside air and discharges it to the outside. In winter the heat pump reverses itself, draws heat from outside air, and delivers it to the inside. Completely automatic operation of the reversing cycle is made possible by the development of a simplified transfer valve for refrigerant flow control. This device when connected with a wall thermostat automatically switches the unit from heating to cooling, and conversely. For further information, write the Westinghouse Electric Corporation, Air Conditioning Division, Department *T-356*, 200 Readville Street, Hyde Park, Boston 36, Mass.

Fine Fibered Pipe Insulation. Owens-Corning Fiberglas Corporation now is manufacturing a finer fibered preformed pipe insulation which includes all the advantages of the old product plus more resistance to abuse, easier handling, and improved thermal efficiency. For use at temperatures from subzero to 450 degrees Fahrenheit, the new pipe insulation, like the old product which it replaces, is available with canvas coverings or vapor seal jackets for cold lines and with a waterproof felt jacket for outdoor use.

Remote Sync Hold Unit. Federal Telecommunication Laboratories, a division of International Telephone and Telegraph Corporation, have added a Remote Sync Hold unit to their line of studio television equipment. Designated as the *FTL-87A*, it is designed to bring a studio synchronizing generator into exact synchronization with the sync component of a remote video signal. This is accomplished on a

(*Continued on page 54A*)

FOR TESTING AND INSPECTION



LABORATORY CUTS TEST TIME WITH G-E HI-POT TESTER. NO CAGES OR TAPE NEEDED.

Bendix Aviation Uses G-E Hi-Pot Tester To Maintain Quality and Cut Test Time

The Pacific Division Development Laboratories of Bendix Aviation Corporation, Burbank, Calif., develops and manufactures equipments for the electronic and aviation industry. To assure quality products, they use General Electric high-potential testers. R. M. Combes, Chief Engineer at the Laboratory, says, "The product is used to maintain quality control, for continuity and good soldered joints. It measures breakdowns as far as wiring and switching relays, and stability of relays are concerned; and in production it is a standard piece of test equipment to maintain quality."

MINIMIZES TESTING HAZARDS

Because the output current of the G-E tester is limited to a maximum of 5 milliamperes, no barriers, cages, or white tape are needed while testing.

BULLETIN AVAILABLE

Price is $226.20.* For further information, check coupon for Bulletin GEC-700.

Viscosity checks can be made quickly and easily—usually in about 20 to 40 seconds.

Viscosities Easily and Accurately Determined with G-E Zahn Viscosimeter

- Easy to use—no special skill required.
- One-piece construction of the stainless-steel cup reduces danger of breakage.
- Retains accuracy—the orifice will maintain its size for years.
- Resists corrosion—viscosimeter may be left in the liquid between readings.
- Eliminates confusion of converting viscosity units.
- One, simple operation.

For further information check coupon for Bulletin GEC-339.

G-E Insulation-resistance Meter Cuts Insulation-failure Rejects

Reduction of rejects due to insulation failure is easily accomplished with a General Electric insulation-resistance meter.

Insulation-resistance meter requires no hand cranking, thus saves valuable time.

Since the maximum output current is limited to two milliamperes, the meter can be operated safely. It can be used wherever 115-volt, 50- or 60-cycle power is available. Insulating resistance can be measured over a range of 0–20,000 megohms. Price $304.20.* Check the coupon for GEC-753.

* *Manufacturer's suggested retail price.*

Section 605-58
General Electric Company
Schenectady 5, N. Y.

Please send me the following bulletins (describing products on these and the foregoing two pages):

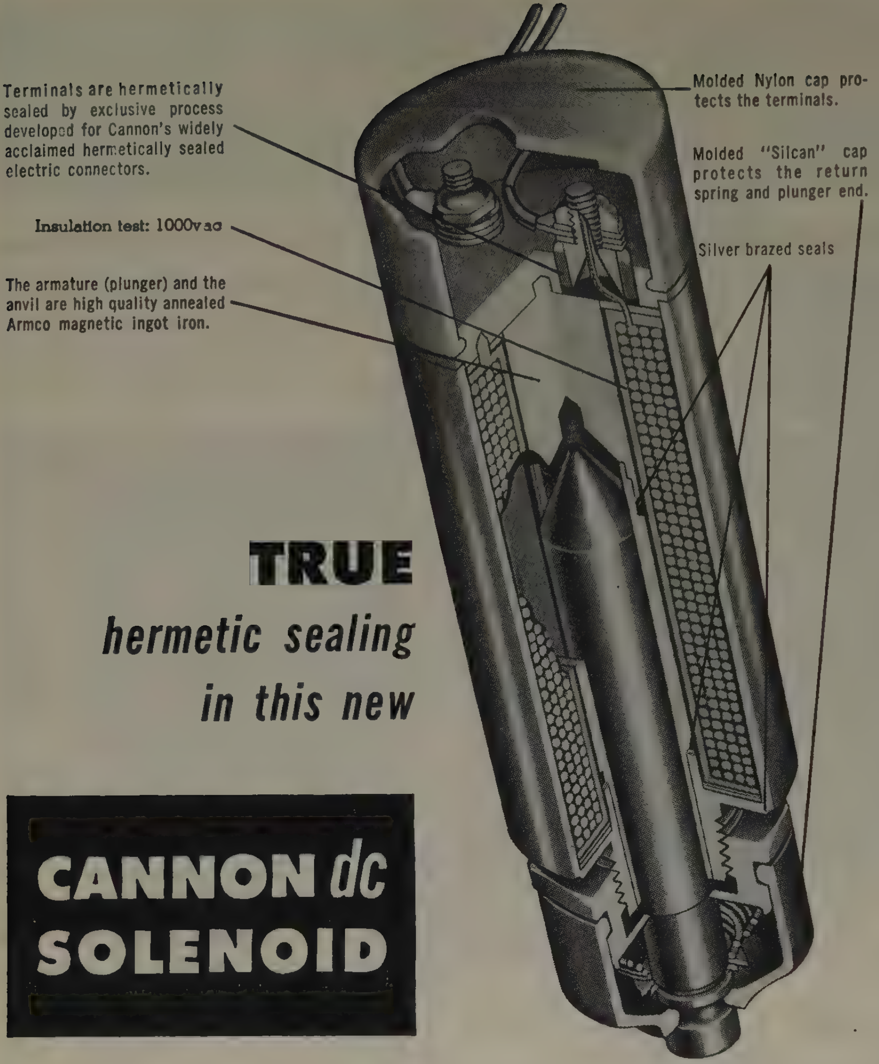
☐ Measuring Equipment Catalog (GEC-1016A)
☐ Molecular Vacuum Gage (GEA-986)
☐ Type PM-10 Oscillograph (GEC-449)
☐ Type PM-18 Oscillograph (GEC-580)
☐ Vibration Equipment (GEC-853)
☐ Insulation-resistance Meter (GEC-753)
☐ High-potential Tester (GEC-700)
☐ Zahn Viscosimeter (GEC-339)

NAME ....

COMPANY ....

STREET ....

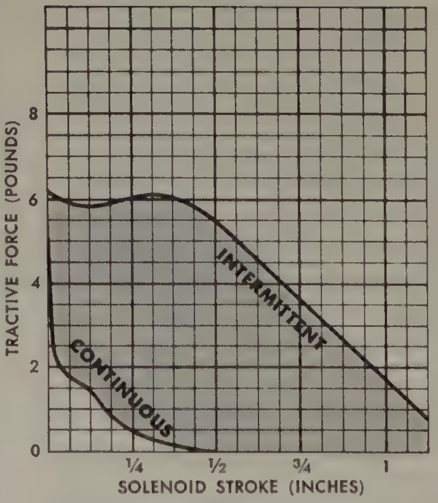
CITY .... ZONE ...... STATE ....


Terminals are hermetically sealed by exclusive process developed for Cannon's widely acclaimed hermetically sealed electric connectors.
Insulation test: 1000vac
The armature (plunger) and the anvil are high quality annealed Armco magnetic ingot iron.
Molded Nylon cap protects the terminals.
Molded "Silcan" cap protects the return spring and plunger end.
Silver brazed seals

TRUE
hermetic sealing
in this new

CANNON *dc*
SOLENOID

For pressurized or corrosion resistant service, Cannon's dc Solenoids offer positive hermetic sealing, sound construction, painstaking workmanship and highest quality materials. A vitreous insulating material is heat-fused to shell and contact terminals, creating a perfect seal. Other parts are silver brazed. The entire solenoid is then copper-nickel-chrome plated to insure complete coverage, high corrosion resistance and long, trouble-free service. Solenoid No. 19760, above, the first hermetically sealed product of this type, is built for continuous duty on 28v dc systems. Fitted with other coils, it renders intermittent duty as characterized by the chart at right. Cannon's hermetically sealed solenoid series reflects the same uncompromising attention to details of sound design, engineering and workmanship that has made the name "Cannon" synonymous with "quality" for more than 38 years. For complete information write for new Solenoid Bulletin DCS4-1953 showing 105 different assemblies.



Solenoids of the hermetically sealed 19760 series, through modification of the coil windings, can meet various characteristics and specific applications within the limits indicated above.

CANNON ELECTRIC
Since 1915
CANNON ELECTRIC COMPANY, LOS ANGELES 31, CALIFORNIA
Factories in Los Angeles, Toronto, New Haven. • Representatives in principal cities. Address inquiries to Cannon Electric Company, Dept. L-117 Los Angeles 31, California.

(*Continued from page 46A*)

gradual basis, so that a local program will not roll on home receivers while the sync generator is being locked to the remote sync. Once local-remote synchronization is established, montages, superpositions, and other special effects can be produced using both local and remote or network video signals simultaneously through the use of additional units such as the *FTL-93B* Poly-Efex Scanner.

225-Ampere Circuit Breaker. I-T-E "*J*" frame circuit breaker is more compact than former 225-ampere design without sacrificing any protective features. Measuring only 9 inches wide by 11 inches in length and 5½ inches deep, the *J* frame saves space in switchboards, distribution-type panelboards, power panels, bus plugs, combination motor starters, and individual enclosures. New design features include enclosed terminals that provide added safety and reduce the possibility of phase-to-phase faults. External instantaneous trip adjustment provides five separate instantaneous trip-point settings. Solderless pressure-type cable connectors allow quick and easy cable connection. Rear connection studs simplify switchboard mounting. The *J* frame is a thermal-magnetic circuit breaker with quick-make, quick-break operating mechanisms. Common trip operation is retained; an overcurrent on any pole opens all poles simultaneously. Extra auxiliary devices such as shunt trips, undervoltage trips, auxiliary and alarm switches are mounted internally within the breaker case. Additional information may be obtained from I-T-E Circuit Breaker Company, 19th and Hamilton Streets, Philadelphia 30, Pa.

Constant Wattage Ballast. The Line Material Company has made available a new CW (constant wattage) ballast for use with *EH-1* mercury vapor lamps. Designed for application on 115- or 230-volt circuits, the ballast assures uniform light output, provides improved open-circuit characteristics, and lengthens lamp life. It is a regulated static-type ballast. Lamp wattage varies less than 3 per cent, and the resulting light output is constant, even if the line voltage fluctuates as much as 10 per cent. For further information, write Line Material Company, Milwaukee 1, Wis.

Pulse-Forming Network. A new universal pulse-forming network, specifically designed for laboratory use in radar research and development, was announced recently by the Sprague Electric Company. The construction of this network makes it possible to obtain the five most-needed pulse lengths, 1/4, 1/2, 1, 2, and 3 microseconds, with no distortion of the pulse shape. The flat portion of the pulse form is retained at all pulse lengths. Common capacitor connections are switched at half

(*Continued on page 58A*)

for poor cable—products like Amerclad"

EVERY SPECIAL JOB

- mold cured portable cord
- machine tool & building wire
- special purpose wire & cable

WIRE & CABLE

SEND THE COUPON

American Steel & Wire
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☐ Please give me more information about Amerclad.
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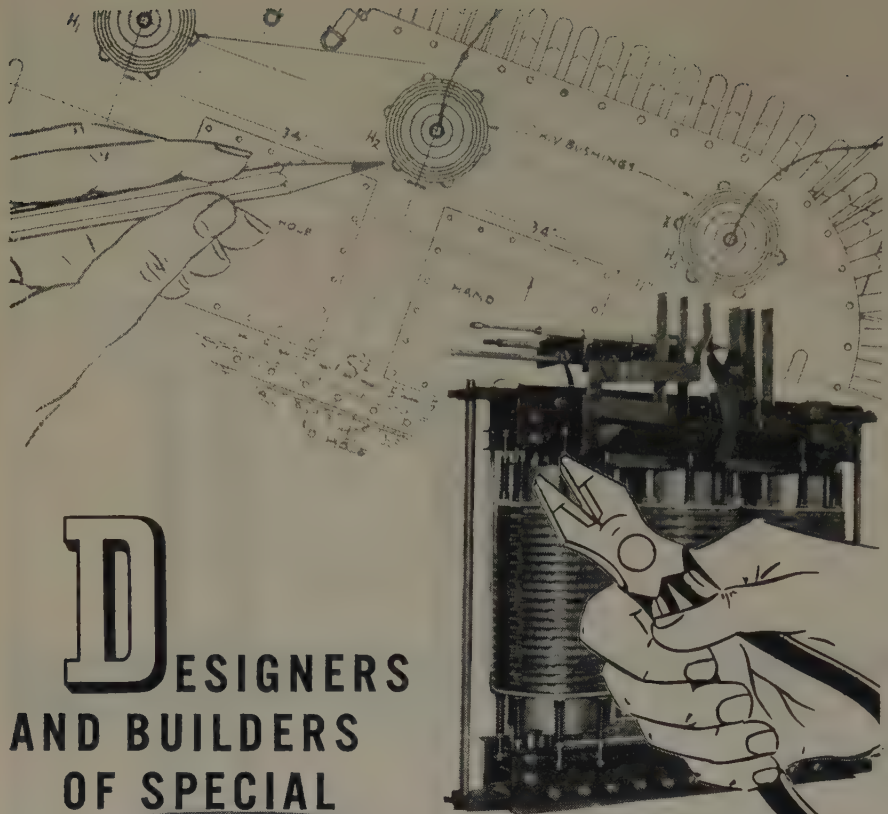
UNITED STATES STEEL



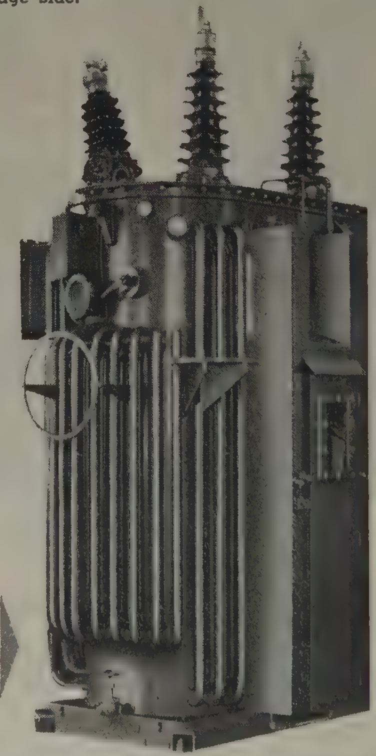
DESIGNERS AND BUILDERS OF SPECIAL TRANSFORMERS

Type AT power transformer, 1500 KVA, three phase, 60 cycle, 69,000Y volts primary, 240/480 volts secondary. Core and coil assembly, low voltage side.

DESIGNING . . . Designing transformers for special functions is a service STANDARD engineers are well qualified to render. You can save time by using STANDARD'S design service when ordering transformers for specific projects, including power, distribution, metering and testing.

BUILDING . . . Your specially designed transformers are manufactured under the watchful eyes of the designing engineers. Every step in the process of manufacture is performed by skilled transformer specialists. ASA standards are met or exceeded. Call your nearest STANDARD representative for information on this useful service.

Type ATAB power transformer, 1500 KVA, three phase, 60 cycle, 69,000Y volts primary, 480/240 volts secondary. Equipped with hot spot temperature indicator and control, provisions for future forced air cooling, pedestals for mounting station type lightning arresters, low voltage terminal chamber and automatic gas seal equipment.



Standard
THE STANDARD TRANSFORMER COMPANY
Trade Mark ®

WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

(Continued from page 54A)

network voltage. All pulse lengths correspond to the half-power point, as measured by the standard synchroscope setup at 70-per-cent voltage level under resistant load. This network is designed for operation with a 50-ohm impedance load. Peak voltage rating is 13 kv regardless of the pulse length used. Complete information will be sent upon letterhead request to Sprague Electric Company, 321 Marshall Street, North Adams, Mass.

TRADE LITERATURE

Handling Tools Catalogue. A complete line of handling tools designed specifically for high-voltage switches, fuses, and cutouts is described in a new Handling Tools Catalogue. Among the new tools are socket-type fittings for removing and replacing *SMD*-type fuses. Listed in the catalogue are 17 universal poles in lengths from 4 to 20 feet, with diameters of $1^1/_4$, $1^1/_2$, and $1^3/_4$ inches. The new Catalogue Section *823* on Handling Tools may be had by writing the S & C Electric Company, 4435 Ravenswood Avenue, Chicago 40, Ill.

Steel Tubing Brochure. A 12-page $8^1/_2$- by 11-inch brochure presents factual data on the use, fabrication, and physical properties of General Motors small-diameter steel tubing. Complete tables and data cover mechanical properties, diameters, tolerances, wall thicknesses, and pressure tests for all of the company's single and double wall tubing. Included are sections on forming, standard finishes, cutting and machining, and joints. Copies of the brochure may be had on request from Rochester Products, Division of General Motors, Rochester 3, N. Y., attention of the Engineering Sales Department.

Noark Safety Switches. A bulletin containing complete information on all Federal Noark Safety Switches has been issued by Federal Electric Products Company, 50 Paris Street, Newark, N. J. Described in detail are the many patented features of the company's line of safety switches, including the only front-operated visible-blade switches of this type on the market. Enclosure types and sizes, knockout sizes and locations, and other ordering information are fully listed.

Allied Radio Catalogue. The 1954 edition of the Allied Radio Corporation's general catalogue has been released. The catalogue contains 268 pages listing more than 20,000 items, with special emphasis on equipment for industrial maintenance, research, and production requirements. Included are sections on public address

(Continued on page 60A)

THE FIRST INSTALLATION of 120 vertical radial gas engine power units in the Point Comfort, Texas, plant of the Aluminum Company of America, included 40 Elliott vertical generators. An additional installation of 74 more units, recently completed, has Elliott generators throughout.

These latest generators are vertical 360-rpm units with a D-C rating of 1200 kw, 667 volts with additional take-off of 150 kva of 3-phase, 24-cycle, 425-volt A-C for engine auxiliaries. All engines are Nordberg vertical type.

It is naturally gratifying to Elliott engineers to have this endorsement of their successful participation in this outstanding power development.

ELLIOTT Company

Ridgway Division
RIDGWAY, PA.

Plants at: JEANNETTE, PA. • RIDGWAY, PA.
AMPERE, N. J. • SPRINGFIELD, O. • NEWARK, N. J.
DISTRICT OFFICES IN PRINCIPAL CITIES

Century

PAVES THE AIRWAY TO INTELLIGENT DESIGN

The Century Model 408 Recording Oscillograph is rapidly becoming "standard of the industry." It has been designed and built expressly for mobile and airborne operation. As with all Century industrial instruments, the Model 408 Oscillograph incorporates the utmost in modern design and workmanship resulting in simple and efficient operation and maintenance.

Century GEOPHYSICAL CORPORATION
TULSA, OKLAHOMA

4447 No. Bodine, Philadelphia 40, Pa.
3406 W. Washington Blvd., Los Angeles 18, Calif.
238 Lafayette St., Dayton 2, Ohio
309 Browder St., Dallas, Texas
EXPORT OFFICE 149 Broadway, N. Y. City

(*Continued from page 58A*)

equipment, recording equipment, technical books, television, and a kit builders' section. The 1954 buying guide may be obtained without charge from Allied Radio Corporation, 100 North Western Avenue, Chicago 80, Ill.

Slidefilm on Gas Turbines. A new sound-color slidefilm on the uses, advantages, and manufacture of the gas turbine for gas pipe-line pumping is now available. The 12-minute film, called "The El Paso Story," shows the application of the General Electric gas turbine to the long-distance transmission of natural gas. The film centers around the Cornudas, Tex., compressor station of the El Paso Natural Gas Company's Southern Mainline where the first of 28 5,700-horsepower gas turbines for the El Paso gas transmission system between west Texas and California were placed in operation, but includes scenes showing the manufacture of the gas turbine. Arrangements for viewing the slidefilm can be made through the nearest Apparatus Sales Office of the General Electric Company.

Miniature Multitester Data. A recent Data Sheet giving information on a Miniature Multitester combination volt-ohm meter for testing resistances and alternating or direct voltages has been announced. Weighing but 12 ounces, this tester is designed for electronic equipment servicemen to use in the field. It has four d-c ranges reading to 300 volts, four a-c ranges to 600 volts, and four resistance ranges reading to 2,000,000 ohms. For a free copy of the Data Sheet, write to International Instruments, Inc., P. O. Box 2954, New Haven 15, Conn.

Pyrometer Supplies. Honeywell pyrometer supplies are illustrated and described in the newly revised Buyers Guide, *100–5*. All general thermocouple assemblies and components are listed, as well as many special-purpose items. Prices and several pages on selection, care, and application of thermocouples are included in this 48-page catalogue available from Minneapolis-Honeywell Regulator Company, Industrial Division, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Self-Supporting Aerial Cables. A new 8-page booklet, "Dimensions and Characteristics of Okolite-Okoprene Self-Supporting Aerial Cables With Aluminum Conductors," provides the physical and electrical characteristics of self-supporting aerial cables with aluminum conductors. Complete dimensional information and current-carrying capacity tables are included. The combination of this construction's light weight, and somewhat lower cost in comparison with comparable cables with copper conductors, is of particular interest to utilities and con-

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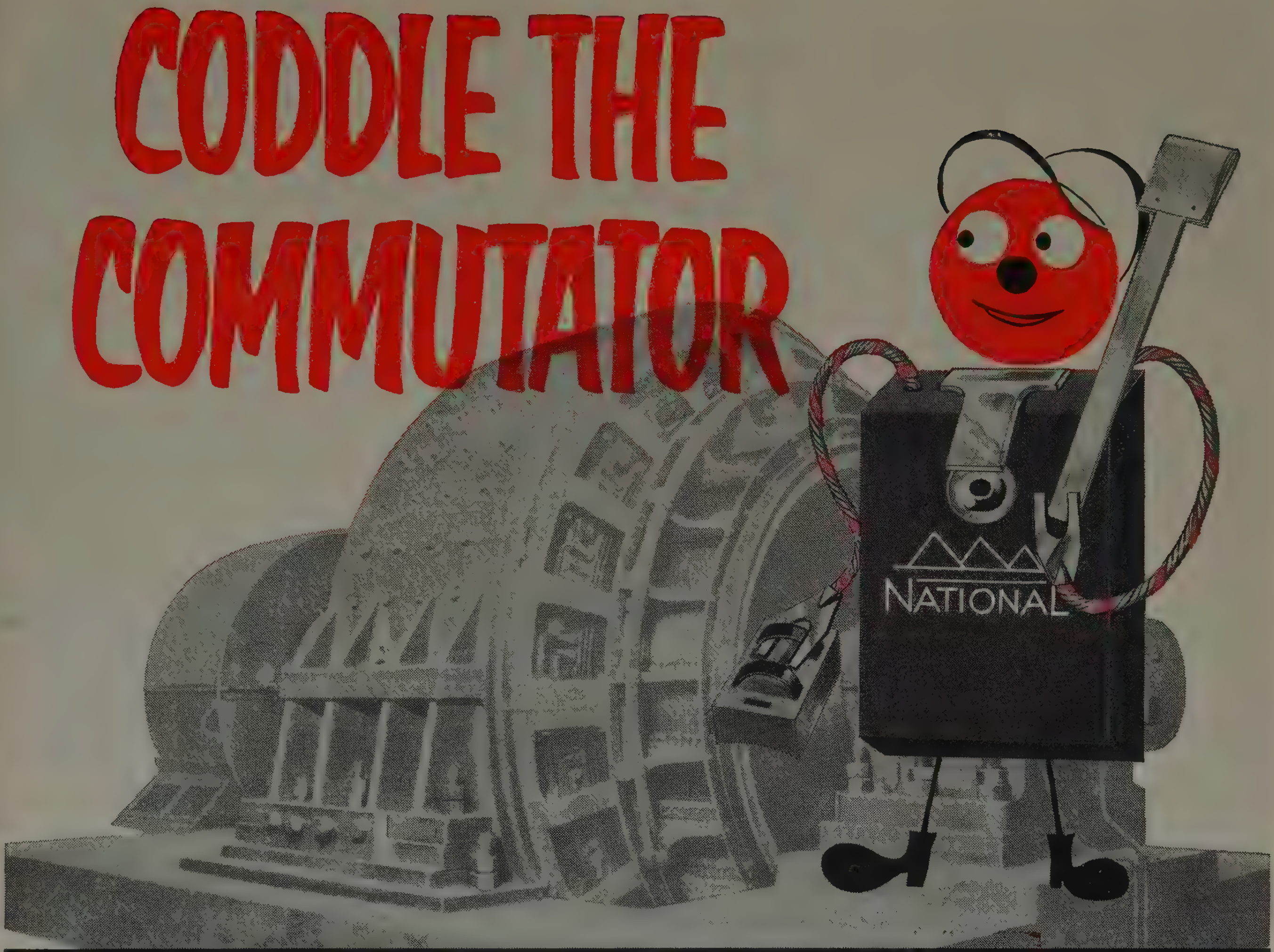

WITH NATIONAL BRUSHES FOR
TRADE-MARK
MAIN-DRIVE, MILL-TYPE and GENERAL-PURPOSE MOTORS

PROPERLY MAINTAINED, commutators are among the least of your operating worries. Neglected, they can cause reduced efficiency, shortened brush life, costly down-time — even, in extreme cases, shutdown of production.

AT THE COMMUTATOR, more than at any other motor component, *minutes,* regularly spent on care, add *hours* to the period between overhauls. Coddle the commutator, and your motors and generators will return your investment many times over.

AN IMPORTANT PART of commutator care is the proper selection of brushes, brushes that give peak commutation . . . low friction . . . proper surface film — "NATIONAL" BRUSHES!

SATISFY THESE CONDITIONS and your brushes will *last* longer, too — as "National" brushes are known to do!

How good is really good brush performance?
– Try "National" brushes and see!

NATIONAL STANDARDIZED BRUSHES

BETTER– PRODUCT–PACKAGE–PRICE–FASTER

The term "National", the Three Pyramids device, and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City,
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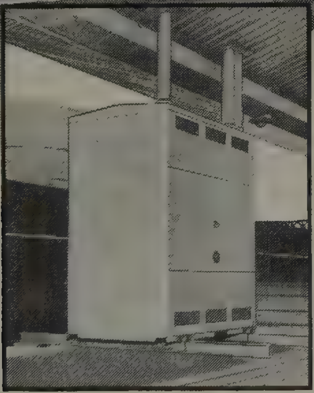


SANTA FE RAILWAY
UNION PACIFIC RAILROAD
SOUTHERN PACIFIC COMPANY

Specifications for the stringent power requirements for Los Angeles Union Passenger Terminal were set up by a group of electrical engineers representing the three railroads that operate the terminal, and were met by the purchase of Marcus dry type Transformers.

The installation consisted of 12 Marcus 300 KVA, 3 Marcus 225 KVA dry type Transformers installed outdoors. All Marcus dry type Transformers are now being constructed with Hi-Heat, Hi-Dielectric Magnet Wire, insulated with DuPont's Newest miracle polyester film "Mylar," combined with Johns-Manville "Quinterra" to reach insulation levels at least 10 times present industry standards.

Increase your power performance standards with Marcus dry type Transformers.

Capacities from 1 to 3000 KVA

- DISTRIBUTION
- GENERAL PURPOSE
- UNIT SUBSTATION
- PHASE CHANGING
- ELECTRIC FURNACE
- RECTIFIER
- WELDING
- MOTOR STARTING
- SPECIAL

MARCUS MTC

"Mark of Quality"

Representatives
in
Principal Cities

MARCUS
TRANSFORMER CO., INC.
HILLSIDE 5, NEW JERSEY

ONE OF THE WORLD'S LARGEST MANUFACTURERS OF DRY TYPE TRANSFORMERS EXCLUSIVELY

(Continued from page 60A)

sulting and industrial engineers. For copies of the booklet, Bulletin *OK-1064,* write The Okonite Company, Passaic, N. J.

Modernized Disconnecting Switch. The completely modernized "*PMB-236*" disconnecting switch for group operation is described and illustrated in Publication *5305* available from the Advertising Department, Delta-Star Electric Division, H. K. Porter Company, Inc., 2437 Fulton Street, Chicago 12, Ill. This low-cost single horizontal break switch is known for its simplicity, compactness, and ease of operation. Complete listings and dimensions are given in all standard voltage ratings from 7.5 kv, 400 amperes, to 161 kv, 1,200 amperes.

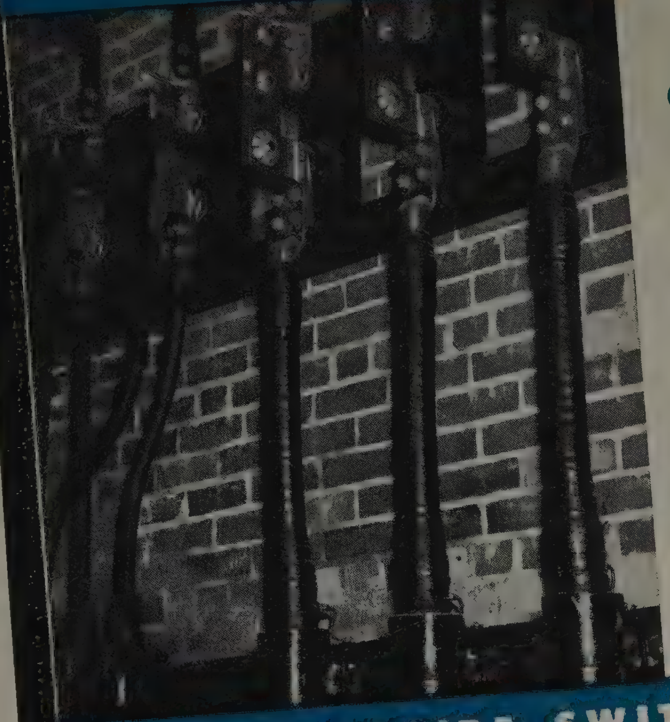
X-Ray Analysis. A new 12-page booklet entitled "X-Ray Methods of Possible Use in Clinical Laboratories" discusses crystallography and X-ray diffraction, identification of compounds, X-ray spectroscopy, and microradiography, and is illustrated with photographs and drawings. It is available free of charge from the Research and Control Instruments Division, North American Philips Company, Inc., 750 South Fulton Avenue, Mt. Vernon, N. Y.

Motor Starters Bulletin. Features of Allis-Chalmers Type *H* starters built to control squirrel-cage, synchronous, wound-rotor, and multispeed motors in ratings from 2,200 to 5,000 volts are described in a new 12-page bulletin. The complete protection features of the starters are covered, and also included are schematic wiring diagrams showing typical methods of control. Copies of "Type *H* Motor Starters," *14B6410B*, may be requested from the Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

Station-Type Cubicle Switchgear. The complete line of Westinghouse station-type cubicle switchgear is described in a new 24-page booklet, *B-5670*, available from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa. Basically, this type of switchgear consists of a large-capacity heavy-duty power circuit breaker, isolating disconnecting switches, connections, and bus, all of which are completely enclosed in a metal cubicle with its circuits and individual phases segregated by metal barriers.

Barber-Colman Catalogue. Complete information on electronic controls and heating, ventilating, and air conditioning is available in a new catalogue, *F 6166.* Descriptive information concerning the ultrasensitive micro relay which simplifies the amplifier is included. Included is a complete description of the various elements required for system application and illustrations of their usage. Requests for the catalogue should be addressed to Barber-Colman Company, Rockford, Ill.

case history



easy to terminate

These Okolite-Okoprene 15-KV shielded cables are installed at the Great Northern Paper Company's East Millinocket Plant, Millinocket, Maine. They typify the ease with which this kind of cable is terminated. No potheads were required. The termination required far fewer manhours of labor, as contrasted with the involved and expensive operation of terminating other types of cables which require a lead sheath. This is one reason why the switch today is to Okolite-Okoprene rubber-insulated high voltage cables.

WHY THEY'RE SWITCHING TO OKOLITE
rubber-insulated cables for use up to 35,000 volts

There is a distinct trend among industrials and public utilities toward Okolite rubber-insulated cables for high voltage use.

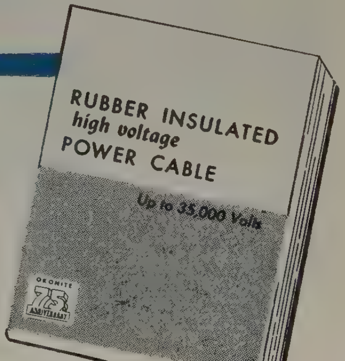
ADVANTAGES

1. **Lighter and easier handling.**
2. **Eliminates sheath corrosion and fatigue.**
3. **Simplifies splicing and terminating.**
4. **Moisture does not affect the insulation.**
5. **No oil migration at high temperatures or elevations.**
6. **Flexibility simplifies installation.**

APPLICATIONS

1. **Transmission and distribution circuits.**
2. **Generator and transformer leads.**
3. **Vertical risers and shaft cables.**
4. **Submarine power cables.**
5. **Portable substation cables and test leads.**
6. **X-ray cables.**

Send for this 128-page manual on rubber-insulated high voltage cable. It provides current carrying capacity tables, dimensional data, engineering information and installation procedures, complete instructions and detailed drawings for splices and terminations. Write for Bulletin EG-1075 on your letterhead to The Okonite Company, Passaic, New Jersey.

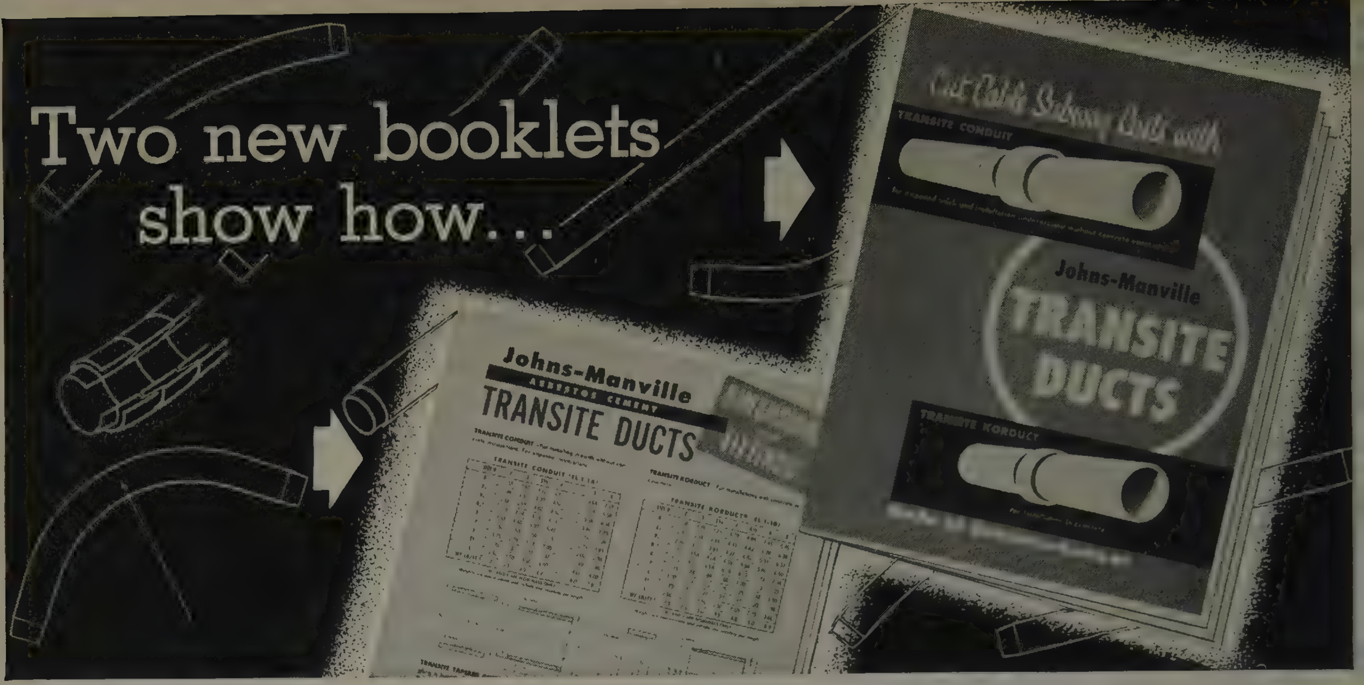


RUBBER INSULATED
high voltage
POWER CABLE
Up to 35,000 Volts

OKONITE PASSAIC, N.J.

OKONITE OKONITE SINCE 1878 **insulated cables**

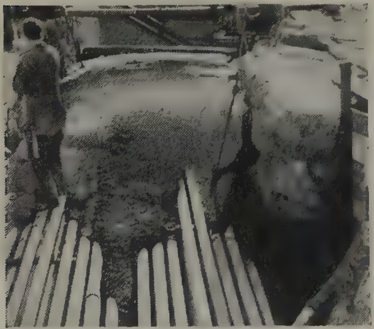
1851



Transite® Ducts cut cable subway costs—

give greater cable protection

Transite Conduit is the thicker walled duct which is used for exposed work or is laid directly in earth without a concrete encasement. Saves time, labor and materials on the job



Transite Korduct® is the thinner walled duct for installation in concrete. Inasmuch as it is used principally for hi-voltage lines, its high thermal conductivity reduces operating losses

● Johns-Manville presents these brochures as a service to public utilities, design engineers, and all other users and planners of cable subway systems. "*Transite Ducts*" shows how improved cable subway protection, installation, maintenance and operational savings may be achieved. "*Transite Ducts, Dimensions and Fittings*" give the necessary dimensional data on all ducts and fittings.

Transite Ducts offer improved cable subway protection. Made of asbestos and cement, Transite cannot burn, smoke, fume or generate explosive gases. Transite confines arc damage and protects adjacent cables against heat and flame. Transite resists corrosive action of soils; is unaffected by electrolysis.

Installation savings result because Transite is strong, light in weight, easy to handle. It comes in long, 10-foot sections, thus, fewer joints are required. Its permanently smooth bore prevents injury to cable either from natural movement or when pulling cable through. Maintenance savings result from the permanent nature of the asbestos cement composition of Transite. It is as durable as stone.

Moreover, operational savings result because cables run cooler due to the high thermal conductivity of Transite Ducts. This also results in prolonged cable insulation life.

For complete details on how Transite Ducts can cut cable subway costs for your system, send for copies of "Transite Ducts," EL-29A and "Dimensions and Fittings," EL-45A. Write to Johns-Manville, Box 60, New York 16, New York. In Canada, 199 Bay Street, Toronto 1, Ontario.

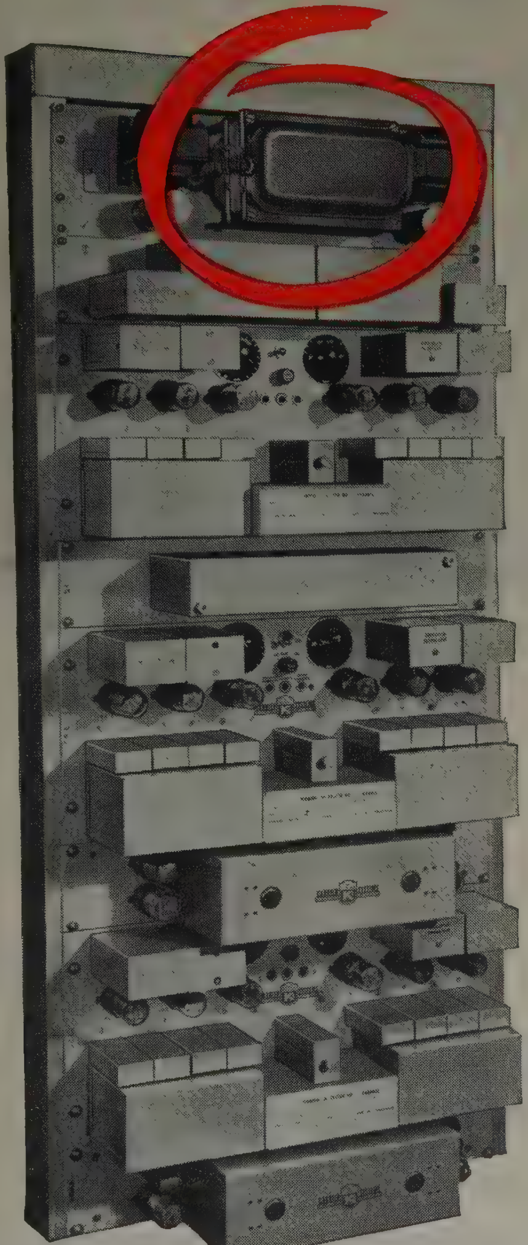
JOHNS-MANVILLE
JM
PRODUCTS

Johns-Manville TRANSITE DUCTS

TRANSITE KORDUCT—for installation in concrete

TRANSITE CONDUIT—for exposed work and installation underground without a concrete encasement

BUILT-IN SOLA REGULATED POWER TRANSFORMER



Assures Positive Signalling and Protects Components

ON KELLOGG NO. 5 TRANSMITTED CARRIER TELEPHONE SYSTEM

Low voltages cause disconnects and false signalling on telephone carrier systems. Abnormally high voltages can result in damage to components and premature filament failure of electronic tubes.

The Kellogg Switchboard and Supply Company provides dependable performance, positive signalling and satisfactory transmission by building in a Sola Constant Voltage Transformer as an integral component of their system's power supply. The custom Sola unit they employed automatically maintains voltage constant within ±3% with line voltage variations from 95 to 125 volts.

Like Kellogg Switchboard, you can assure reliable performance of your electronic equipment. Make sure of the proper input voltage with a Sola Constant Voltage Transformer. Any reasonable combination of plate and filament voltages can be provided to meet your specifications.

Sola stabilizers are static magnetic regulators . . . regulation is continuous and automatic . . . response time is 1.5 cycles or less.

There are no moving parts, no tubes, no manual adjustments. The cost is reasonable. Regulation within ±1% with line voltage fluctuations as great as 30% can be provided. Your inquiry will receive prompt attention.

The photograph above shows a complete Type No. 5 three channel Transmitted Carrier Telephone Terminal made by Kellogg (an Associate of International Telephone and Telegraph Corp.) The Sola Constant Voltage Transformer is a standard component of the power supply chassis at the top of the rack.

BUILD-IN AUTOMATIC VOLTAGE STABILIZATION WITH

SOLA *Constant Voltage* **TRANSFORMERS**

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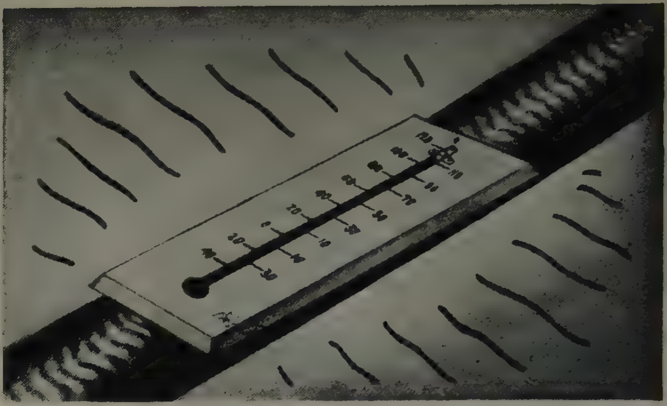
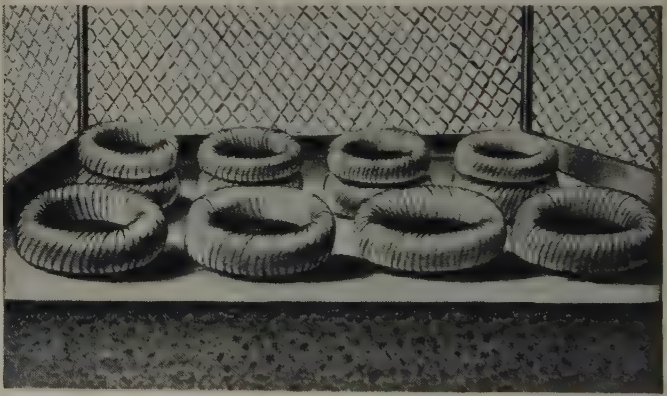
How to prolong the life of wire and cable by proper storage

1 **Protect cables from the weather.** Moisture is especially injurious to fibrous coverings. When stored out-of-doors, if they become wet and then freeze, they will be weakened and the saturant will flake off. In humid weather, mold growth is accelerated, weakening the covering and making it easier to damage the cable during installation. (Rubber and thermoplastic insulated and jacketed cables may be stored under moderately humid conditions.) The larger sizes of fibrous covered and rubber jacketed cables and all lead-sheathed rubber insulated cables must be stored on reels which must be properly lagged—or the cable must be otherwise suitably protected against mechanical damage. Reels can be stored out-of-doors if the cable is protected against sun and weather, and the ends are properly sealed.



2 **Don't expose wires and cables to extremes of temperature.** Chemical reactions occur at a higher rate at high temperatures than low. The greatest deterioration of low-voltage cables is due to chemical changes, oxidation or internal changes in the compound itself. Never store reels in the boiler room unless you use a fan to blow hot air away from the wires and cables. It's best to store cables at room temperatures indoors out of direct sunlight. Rubber insulated cables may be stored and handled without damage at the lowest temperatures ordinarily encountered, but thermoplastic synthetic insulated cables should not be handled at temperatures below −10 C. (14 F.)

3 **Reels should be kept off the ground,** so that moisture will not harm the cables, reel flanges and lagging. Sound reels are easier to handle and there is less chance of injury to the cable as it is removed from the reel.



4 **Coils should be stored one layer deep on the floor or shelves,** with the axis either horizontal or vertical. To save space, they may be stacked, but not more than 5 coils in height—otherwise there is harmful pressure on the insulation. Don't remove brown paper or box that protects against dust and light until used.

5 **Rubber insulated fibrous covered, rubber jacketed or lead-sheathed cables in storage** should never be bent to a diameter less than I.P.C.E.A. recommended diameters. Never let coils or reels drop more than a few inches. Always roll a reel in the direction indicated by the arrow on the flange. When rolling an unlagged reel, put planks under the flanges to avoid pressure on the cable. Coils, reels and spools should always be rotated when wire and cable is removed to avoid twisting the cable.

FREE REPRINTS OF THIS PAGE ARE AVAILABLE. WRITE TO ADDRESS BELOW.

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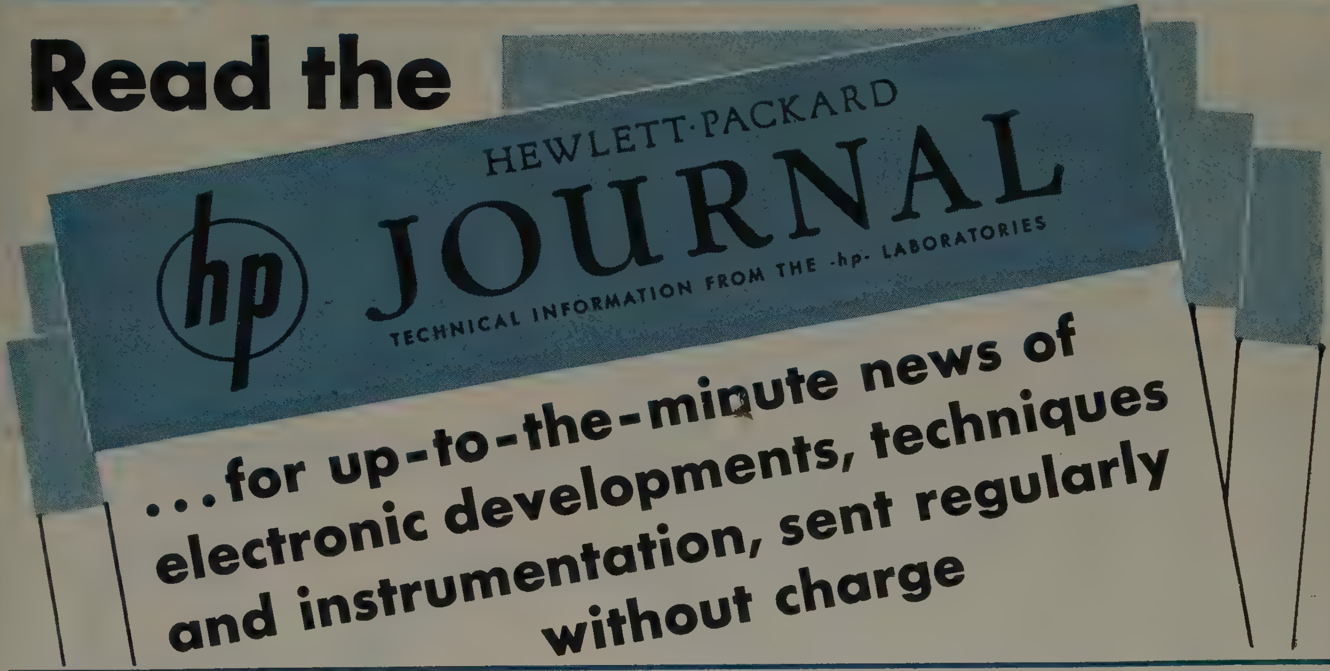
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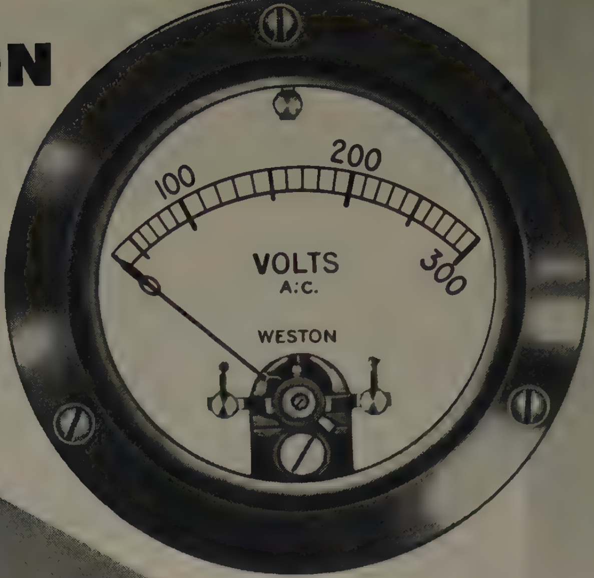
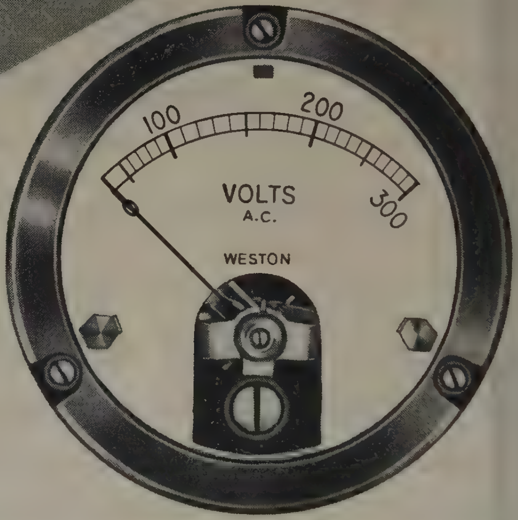
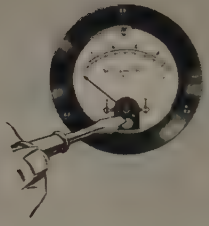


A-C ruggedized instruments





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WESTON ruggedized instruments

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ROETEMP MAGNET WIRE brings you a brand new and superior type of insulation for applications that involve high operating temperatures. Its heat-resistant properties and dielectric strength, its extra toughness and working ease make this new Roebling ROETEMP your top choice for Class B, dry-type transformer windings, and for other electro-magnetic devices designed for operation with hot spot temperatures of 130°C (266°F).

Roebling ROETEMP Magnet Wire is insulated with a specially processed tape applied in a single wrap with a liberal overlap. It is exceptionally pliable and bends without cracking or separating from the conductor. It won't unravel; is ideal for higher speed winding; comes in a range of sizes from #1 to #12 AWG, round, square and rectangular.

Write for full data on Roebling ROETEMP Magnet Wire . . . and Roebling silicone bonded ROEGLAS wires for special temperature problems. John A. Roebling's Sons Corp., Trenton 2, N. J.

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① **Standard Square D Plug-in Control Centers** in Nema I enclosures are designed for the majority of installations.

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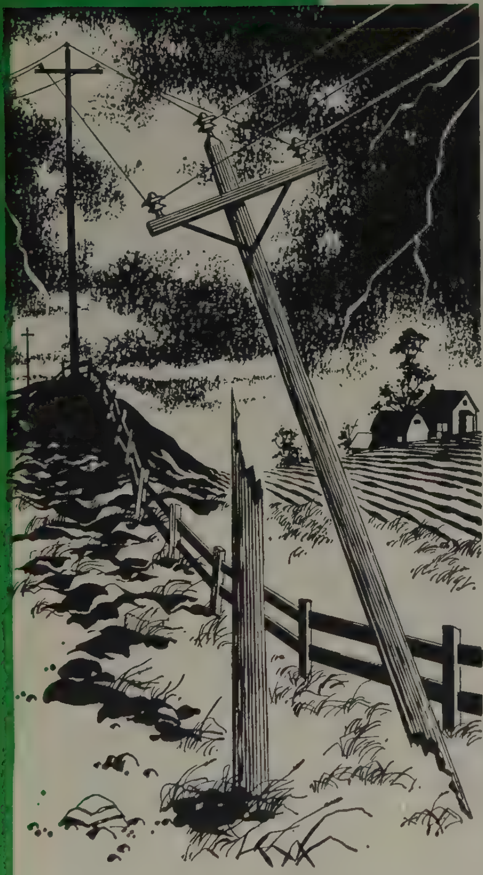
DO YOU USE SWITCHES THAT CAN

BREAK the CIRCUIT

UNDER ANY CONDITION?

(Except Short Circuit)



NOW YOU CAN JUST PULL THE SWITCH

When emergency strikes . . . when an energized line is down . . . the S&C Alduti enables you to drop the load—all of it—at once!

No need to go through complicated unloading preliminaries . . . no need to open main breakers causing otherwise unnecessary interruptions . . . outages are held to a minimum . . . line repair can go forward immediately.

The S&C Loadbreak Switch drops the load with no lost time, NO external arc, and with safety to the operator.

HERE ARE SOME OF THE FEATURES YOU'LL FIND IN THE S&C LOADBREAK SWITCH

- Positive, "clean break" switching
- Safety to operators
- Interruption of all load currents and charging currents
- Independence from adverse wind conditions

Only one switch—the S&C Alduti—can give you all of these essential performance features . . . can break the circuit, and do it with NO external arc.

This is why the Alduti Loadbreak Switch has gained wide preference among power men . . . why leading utilities everywhere specify it for sectionalizing.

S&C

SPECIALISTS IN

your System?

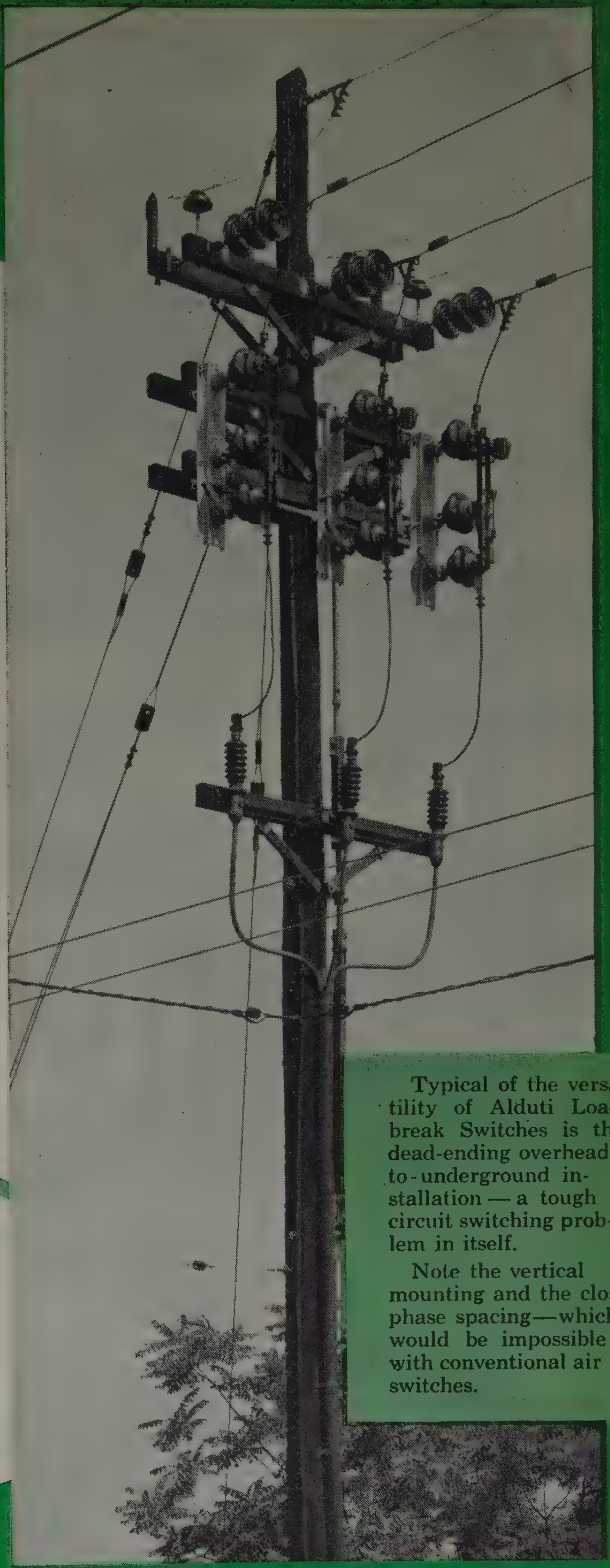
IF NOT, you are missing the kind of operating flexibility you get with the S&C Alduti Loadbreak Switch . . .

The Alduti Loadbreak can be operated *any* time . . . instantly . . . without communicating down the line to find out whether load conditions permit switching . . . a very important advantage during storm and emergency conditions.

With the Alduti, switching operations can be carried out without sequencing with circuit breakers—an important advantage during storm or emergency.

And it can drop your *entire* load . . . individual loads never need to be removed as a preliminary.

Interested? Then write today for literature. It will give you new ideas on sectionalizing.



Typical of the versatility of Alduti Loadbreak Switches is this dead-ending overhead-to-underground installation — a tough circuit switching problem in itself.

Note the vertical mounting and the close phase spacing—which would be impossible with conventional air switches.

ELECTRIC COMPANY

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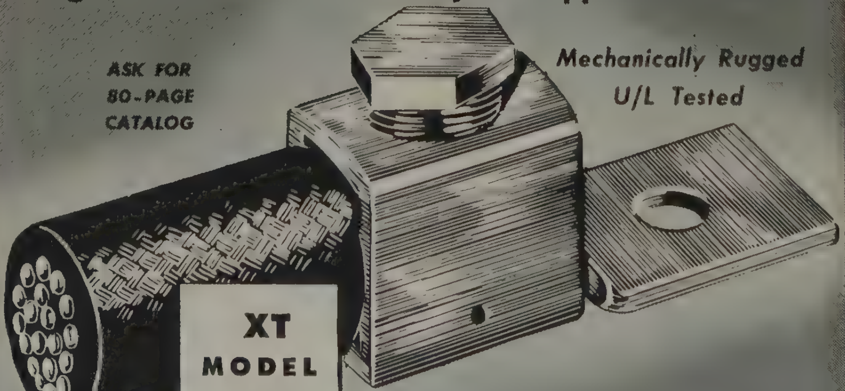

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Upon suggestion by the Standards Committee of the AIEE, the Instruments and Measurements Committee voted in 1941 the appointment of a subcommittee for preparing a Master Test Code for Temperature Measurement. The objective of this action was to amplify, and ultimately replace by a single code, those recommendations on temperature measurement which are applicable to commercial tests on a variety of electric machines and which had been duplicated in separate standards pertaining to specific types of apparatus.

The recommendations in this completed and approved code (number 551, effective as of August 1950) apply to the determination of operating temperature and of temperature rise of all electric machines, instruments, and apparatus in common use, where temperatures do not exceed 500 degrees centigrade. Standards pertaining to permissible temperature rise and corrections are not included.

Price: $0.80 to non-members, $0.40 to members of the AIEE. Orders should be sent to:

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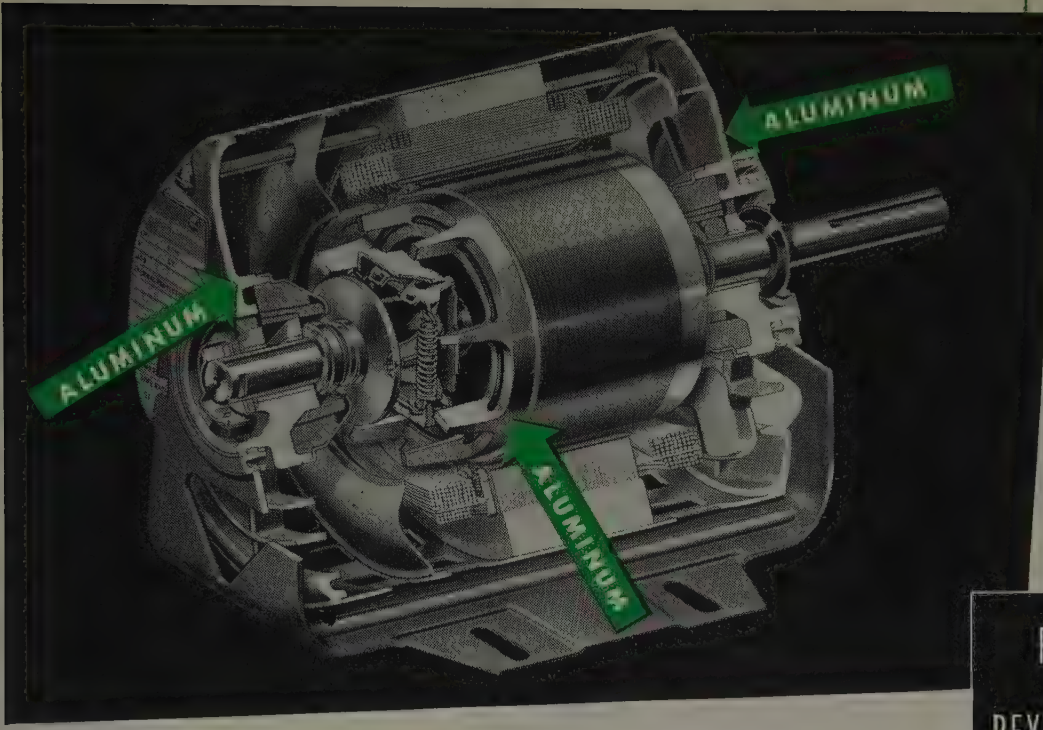

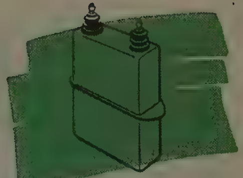
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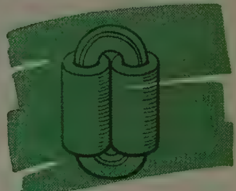
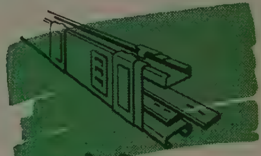

Magnet Wire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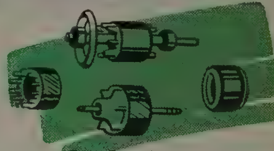
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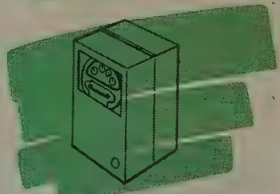
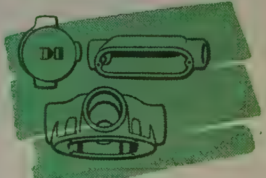

Meter Boxes


Conduit Fittings

Aluminum helps make all-new fractional-hp motor

Smaller...Lighter...More Versatile

General Electric gave industry a brand new concept in motors with its all-new "Form G" fhp motor. These completely new . . . completely different motors give full NEMA performance at up to *50% less weight . . . 40% less bulk, rating for rating!*

Among the new features of this smaller, lighter, more versatile motor is an increased use of aluminum. The newly designed aluminum rotor winding is practically indestructible and is cast integral with the rotor fan blades—making for cooler running. The aluminum end shields help provide neater appearance and better conductivity of heat away from the motor bearings, helping to give longer bearing life.

Perhaps you, too, can find better uses for aluminum for weight saving, neater appearance, heat conductivity, and as an electrical conductor. All in all, from both a manufacturing and the end user's standpoint, aluminum is the ideal metal to use in a great variety of electrical applications and products.

Call on Reynolds Electrical Engineering Service for Help on Your Problems

Reynolds engineers will conduct meetings with your men and provide them with the latest information on electrical applications of aluminum. Also write for a complete index of design and fabrication literature. Reynolds Metals Company, 2541 South Third Street, Louisville 1, Kentucky.

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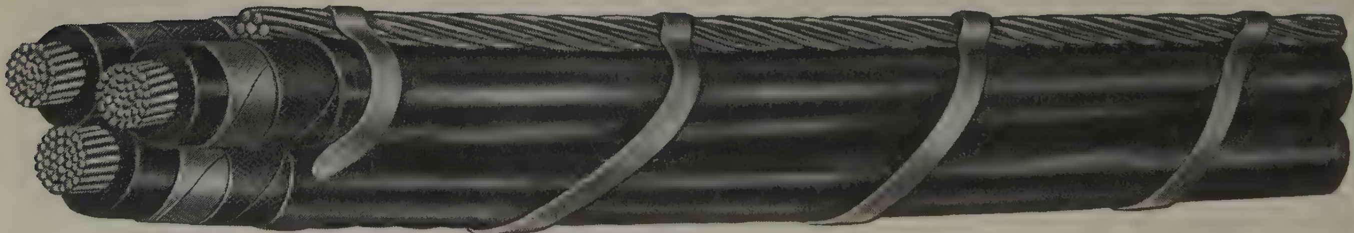
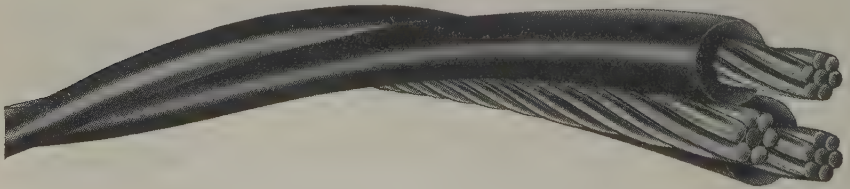
REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND



(ABOVE) **Rome Pre-Assembled Self-Supporting Aerial Cable For Primaries**—Supplied in various designs incorporating RoZone insulation, shielding where needed (generally over 5 KV) and outer protecting coverings of RoPrene (Neoprene) or corrosion-resistant metallic tape in accordance with IPCEA standards.



(LEFT) **Rome Triplex Self-Supporting Secondary or Service Drop Cable**—RoPrene (Neoprene) or RoLene (polyethylene) insulated copper or aluminum power conductors spiraled around a suitable neutral messenger of copper, copperweld, aluminum or ACSR.

Burying Cable on TOP of the Ground

Recently an electric railway company decided on a line extension. Before they could lay the track they had to raise the grade of an existing roadway. Fortunately someone thought of burying the underground signal cable the easy way.

The electric railway scooped out a shallow depression, lined it with sand, put in the Simplex-ANHYDREX Signal Cables, covered them with sand, and then they filled the roadway to a depth of about four feet with fill. The top of the concrete pedestal will be at grade.

The electric railway showed good judgment on two counts. First, they buried the cable in the least expensive way and, second, they used Simplex-ANHYDREX Signal Cable which will give them dependable service for a long time to come.

Why did the railway buy ANHYDREX Signal Cables? Because the Anhydrex insulation will retain its electrical and physical properties indefinitely. This insures long life and dependable operation. The cable is easy to install, splice and terminate. It has no metallic sheath to crack from vibration or deteriorate from electrolysis. It does have a special metallic tape to resist termites, etc.

These are a few of the reasons why railways, public utilities and industrial plants are using ANHYDREX Cables for signal, control and communication services.

Simplex
WIRES & CABLES

SIMPLEX WIRE & CABLE CO., 79 Sidney Street, Cambridge 39, Mass.

Can Insulation Testing Be More Effective?

Certainly....

Development of simpler and more effective insulation-testing methods has attracted considerable attention in the electrical equipment industry. Research and experience have indicated considerable advantage in the application of direct-current overpotential techniques to insulation testing. Our design staff, realizing the need for new equipment, carefully analyzed the problems attendant to modern insulation testing.

The designs evolved from this work were applied to a wide range of industrial applications with a high degree of success.

Industry leaders have found the advantages of simplified overpotential testing using BETA d-c equipment to include the following:

Leakage resistance can be measured *directly* by R = E/I readings at *any* output voltage, thus eliminating the elaborate bridge methods required with a-c tests.

By recording leakage current increase vs time, failure of equipment can be *anticipated.* Equipment, therefore, can be shut down for repair or replacement on planned schedule instead of after an emergency replacement following a failure.

Physical problems associated with testing large equipment are greatly reduced since the d-c testing device can be of limited capacity and therefore of portable dimensions; this is due to the elimination of the capacitance charging current.

Voltages which are equally searching for defects and physical damage are far less damaging than the equivalent a-c voltages.

The slope of the voltage endurance curve is such that the time of voltage application is not nearly so critical as with a-c voltage.

BETA-BUILT d-c overpotential testing equipment incorporates the following features to enable the operator to utilize the above design advantages with maximum convenience:

Mobility—For ratings below 50 KV, the equipment is completely portable. Above 50 KV, the equipment is compact and mounted on casters for ease of mobility. Output terminal and ground shield are removable for truck shipment.

Metering—Multiple ranges are provided on the meter to allow readings of low leakage currents and low output voltages. All meters are *direct reading.* The kilovoltmeter is connected directly across the load and the current meter does not indicate the kilovoltmeter drain.

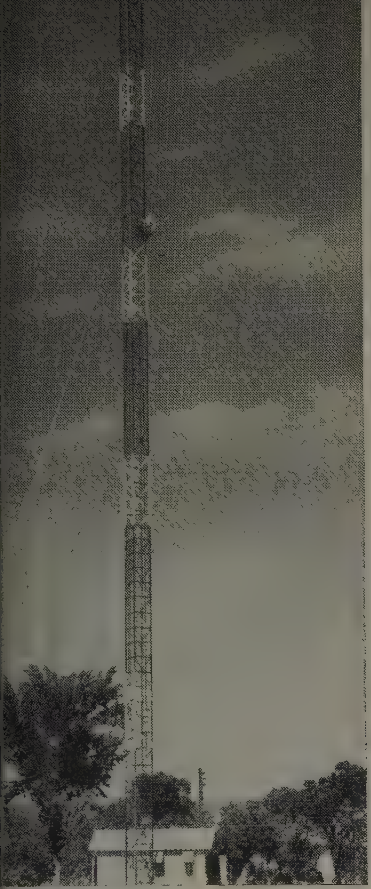
Surge Protection—All meters are protected against sudden short circuits due to failure of insulation under test. All components are conservatively designed to withstand repeated surges at full output voltage.

Standard Components—All circuit components, including rectifiers, are standard catalog items or are always available from BETA stock.

Further information on these techniques is available in a booklet we have prepared, containing a more complete evaluation of the advantages of d-c overpotential testing techniques. Included with this material is a bibliography of recent papers on the subject. Write for your free copy today.

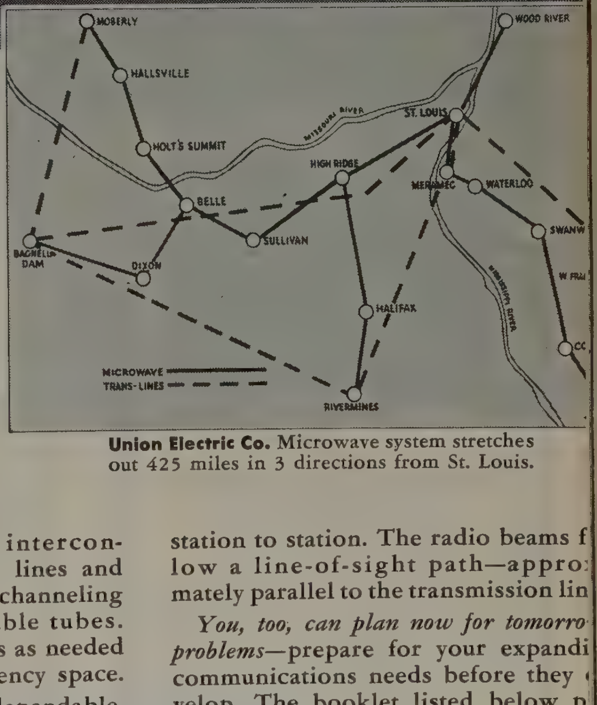
BETA Field Engineers are available throughout the United States for consultation on specific applications of d-c overpotential equipment.

Beta Electric Corp.
333 East 103rd Street, N.Y., N.Y.



CA Microwave radio relay installation t High Ridge, Mo. Towers are rugged, esigned to withstand 100-mph winds nder severe icing conditions.

Osage Hydroelectric Power Plant installation of Union Electric Company of Missouri, at Bagnell Dam, Mo.—serviced by RCA Microwave.



Union Electric Co. Microwave system stretches out 425 miles in 3 directions from St. Louis.

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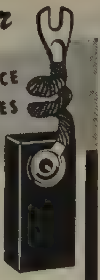

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This American Standard (Z10.5—June 1949), which has been prepared by a subcommittee of the Sectional Committee on Letter Symbols and Abbreviations for Science and Engineering, is a revision of ASA Z10gl and AIEE 17gl.

General principles of letter symbol standardization, a typographical notation for distinguishing, in the equations of the printed page, between the symbols for scalar, complex (phasor), and vector quantities are given, as well as tabulations of the symbols in alphabetical order of the names of quantities, English letter symbols, and Greek letter symbols.

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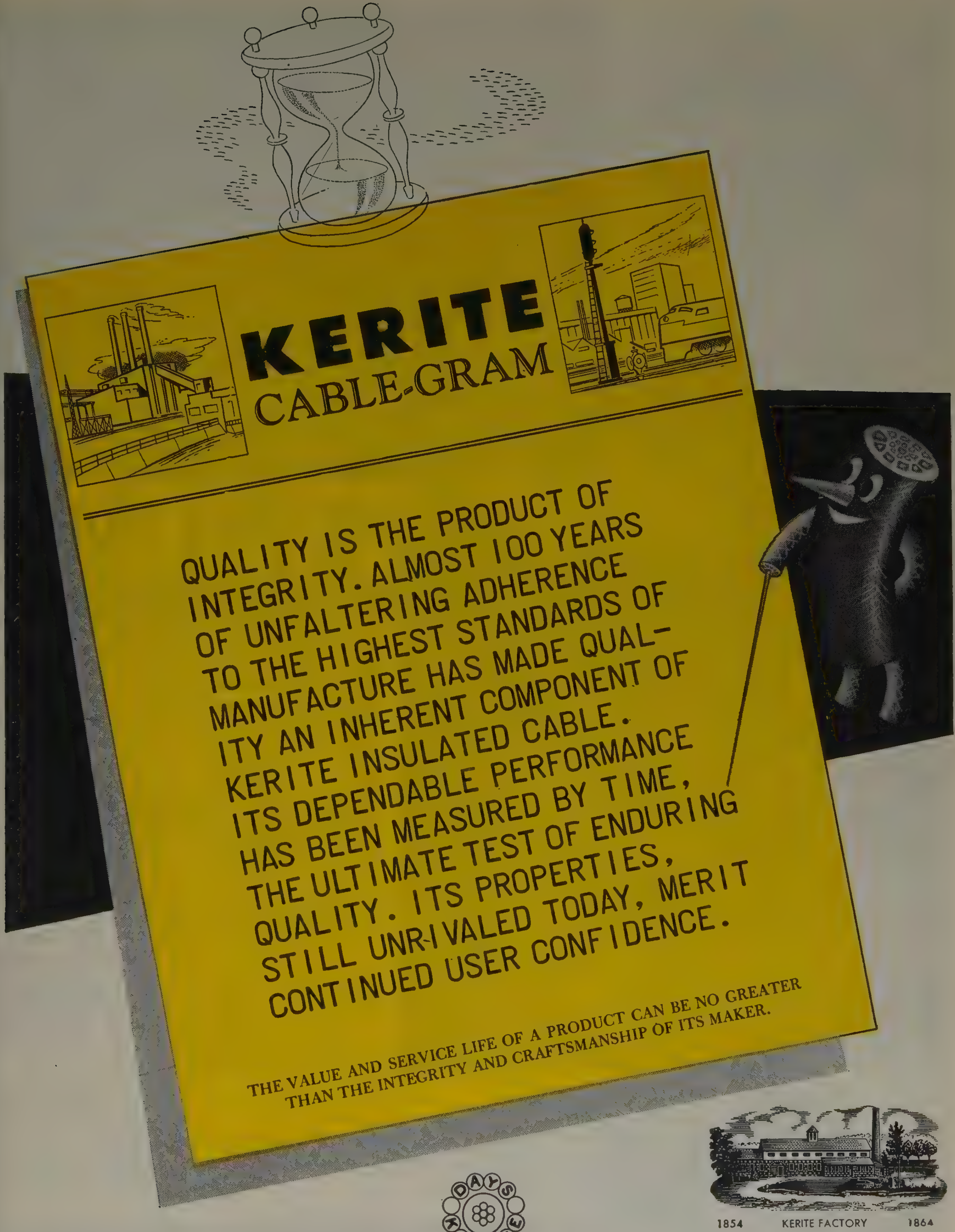

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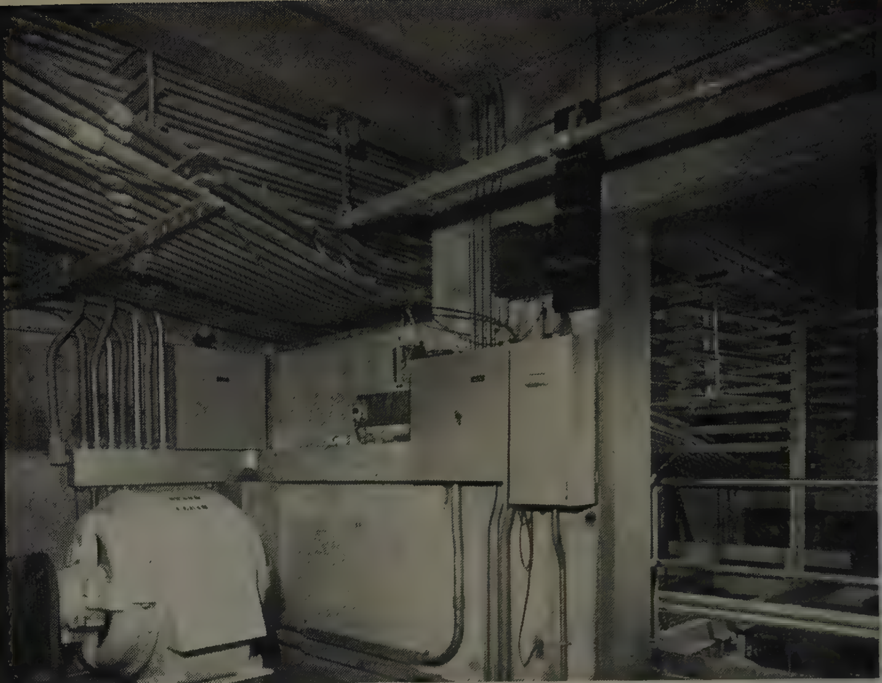
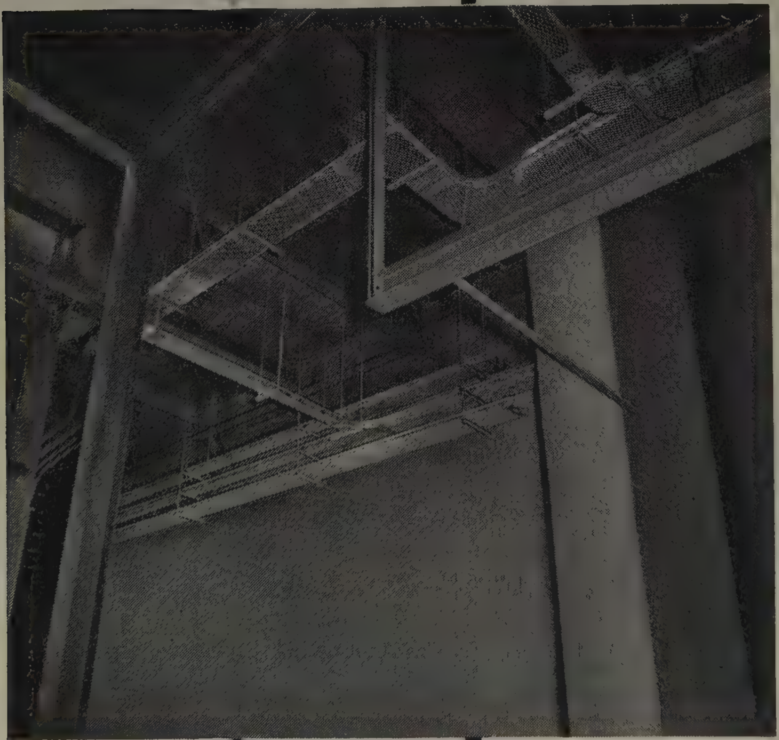


...with COPE CABLE TROUGH



SEEING IS BELIEVING! Here you can see at a glance the time, material and labor savings possible on cable installations through the use of Cope Cable Trough. Both of these photographs were taken at the City of Glendale (California) generating plant. The upper and older installation shows 126 - 1¼″ conduits containing cables for controlling the auxiliaries for two turbine generators. Just look at the tremendous number of bends and fittings, and the complicated hanger construction needed to support this maze of conduit. You can imagine the high cost of engineering, material, and installation this entailed, even before the big job of pulling cable through the conduits was possible.

Now examine the lower, recent installation (view taken during construction) involving control of two additional generators, where cables for control conduits 480 volt auxiliary power, and 2400 volt auxiliary power are carried in Cope Cable Trough. It was a simple job to lay out and erect this trough using standard lengths and fittings. Costs were but a fraction of the older method; time and material were saved and accessibility for visual cable inspection is provided. Additional cables may be added with great ease.

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A detailed bulletin giving all the facts about Cope Cable Trough will be sent upon request. Write for it.

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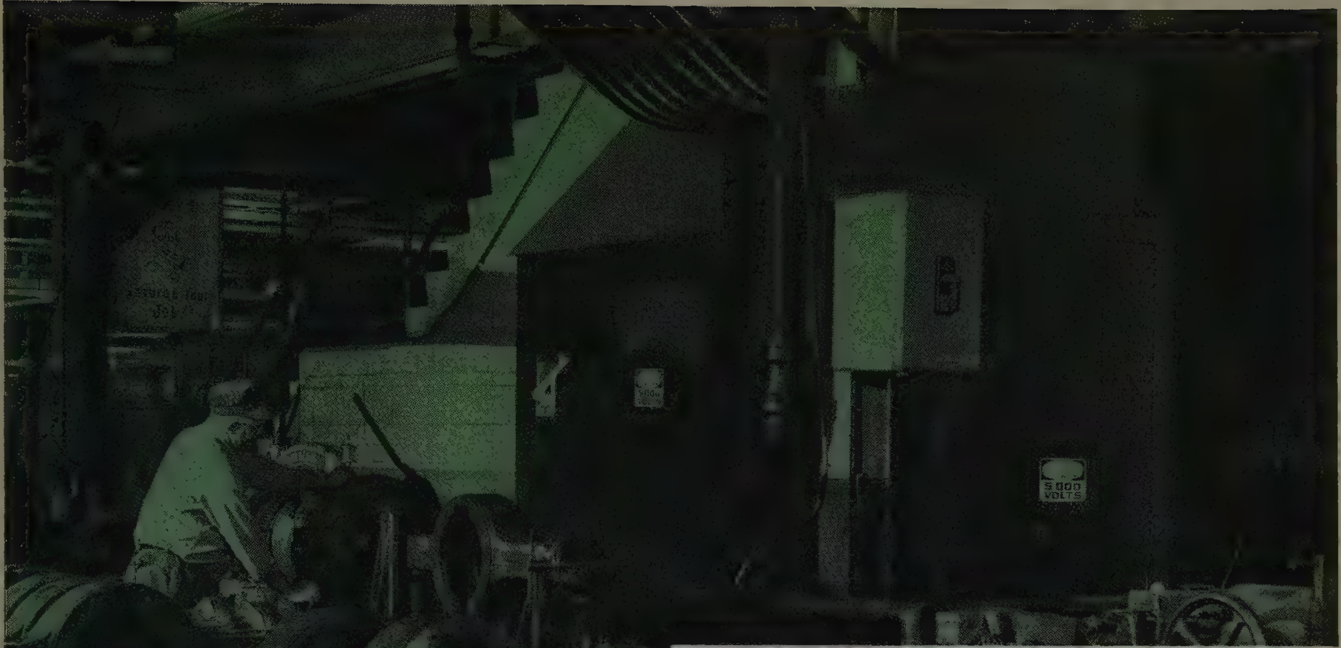
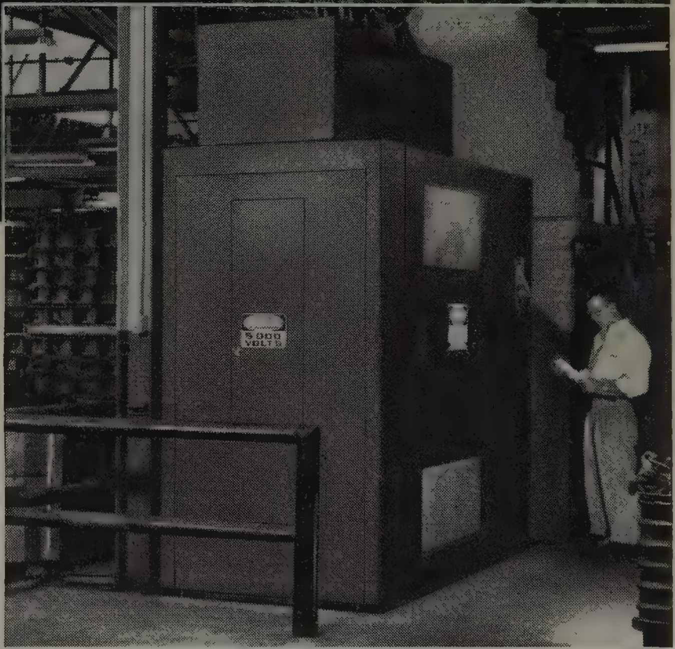


POWER...

Above—one of the two 2,000 KVA unit sub-stations powered by an Uptegraff Dry Type Transformer, located near the assembly line.



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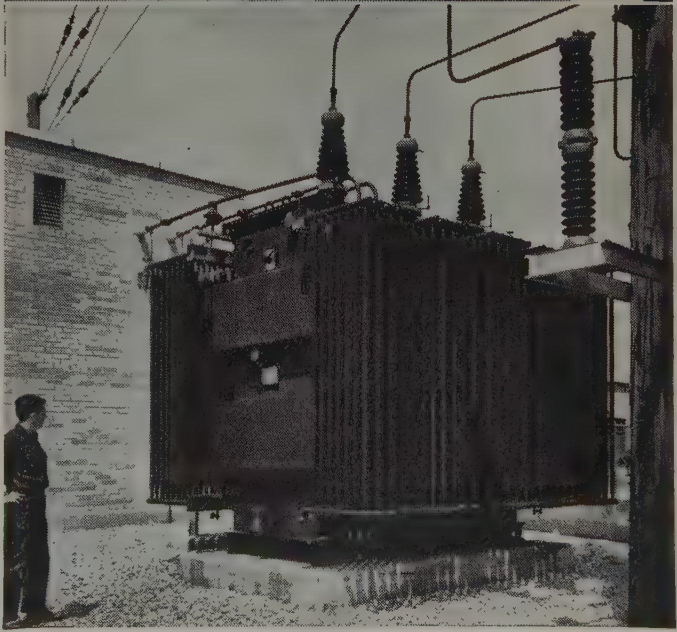
UPTEGRAFF

transformers

Located close to the center of their electrical loads, the Uptegraff Dry Type Transformers shown here serve efficiently in the Newark, Ohio plant of the Ohio Gear and Axle Division of Timken-Detroit Axle Company. Line losses are reduced by the central location of the transformers, and power characteristics are improved. In this plant are two 2000 KVA and two 1000 KVA dry type Uptegraff Transformers. Supplying these indoor dry type Uptegraff transformers is a 6000 KVA oil-cooled Outdoor Power Transformer.

R. E. Uptegraff Manufacturing Co.

Scottdale, Pennsylvania



6000 KVA Uptegraff Outdoor Power Transformer supplying the entire plant is shown at the right.

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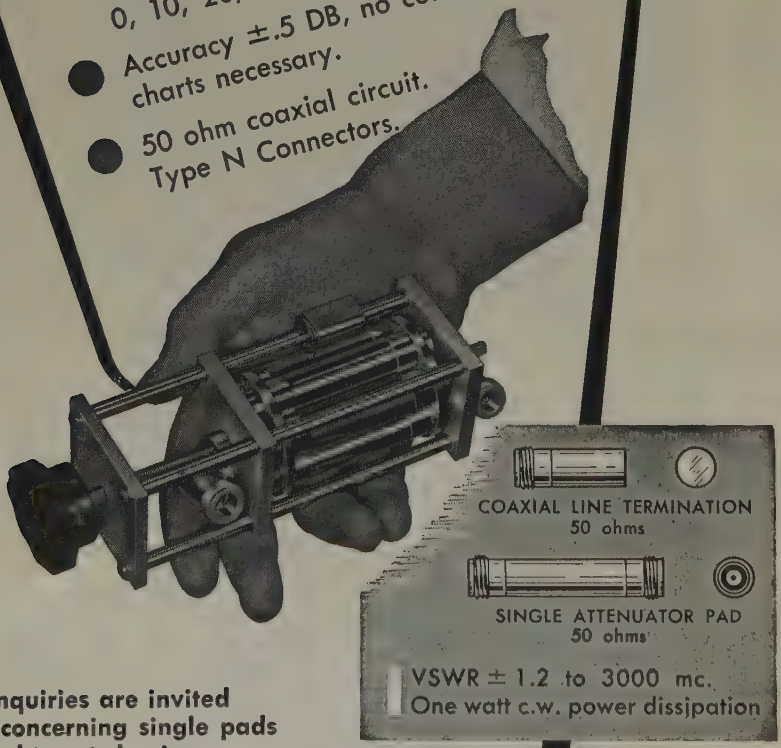

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For easy reference, there is a Subject Section, subdivided into 18 classifications, and an Author Section, which contains a list of about 550 authors. Price: $0.70 ($0.35 to AIEE members).

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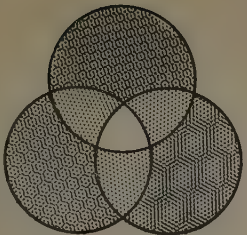

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The National Television Systems Committee has authorized IRE to publish its long awaited Monographs in the January 1954 special Color Television issue of "Proceedings of the I·R·E" — thus giving them industry-wide distribution for the first time in print.

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will also appear in this issue, which brings the reader up-to-the-minute on the developments of Color Television. Copies of the first Color Television issue are still available and combined with this second Color Television issue will form a complete bibliography of major historical importance. Also included in the January issue will be a complete listing of the N.T.S.C. system specifications as submitted to the F.C.C.; and field test reports on the system's performance.

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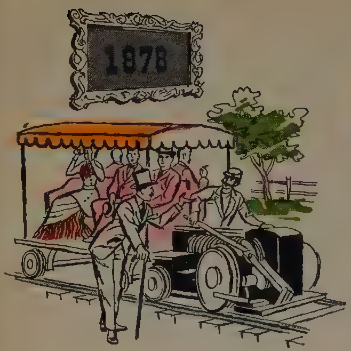

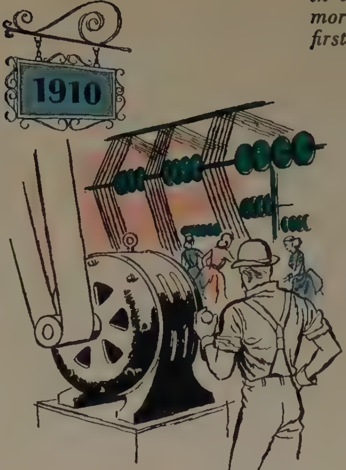

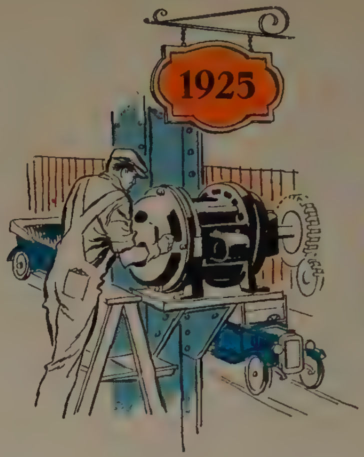

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A NEW MILESTONE IN MOTOR HISTORY

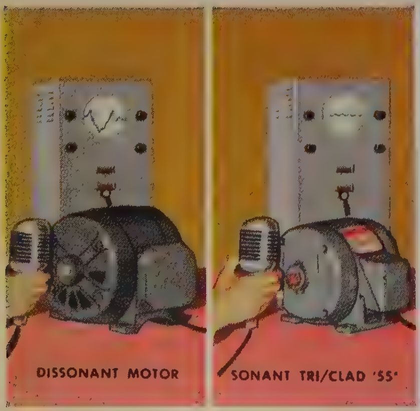
New TRI 55 CLAD motor climaxes 75 years of engineering leadership

REG U S PAT OFF

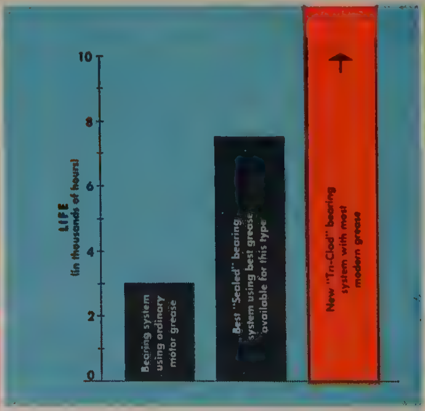
The General Electric Tri/Clad '55' is an important milestone in motor history. For this is a *completely new motor*. Born out of thousands of engineering man-hours, the Tri/Clad '55' incorporates design improvements that go far beyond mere modifications. Many years of pure research, the discovery of new, better materials, the knowledge of how to make better use of present materials, and improved manufacturing processes all make the Tri/Clad '55' motor the new leader in the motor field.

You as a motor user should take the opportunity to see and test this motor for yourself. Contact your nearest G.E. Apparatus Sales Office or G.E. Motor Agent and tell him you want to see the new G-E Tri/Clad '55'. General Electric Company, Schenectady 5, N. Y.

648-4



DESIGNED FOR BETTER PERFORMANCE: Tri/Clad '55' has a low noise level . . . runs cool . . . gives up to 53% increase in shaft output per pound...has higher full-load speeds.



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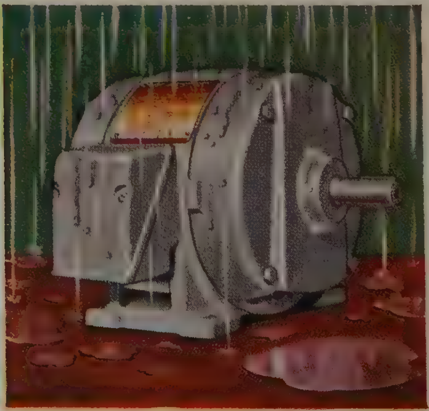

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THIS IS A

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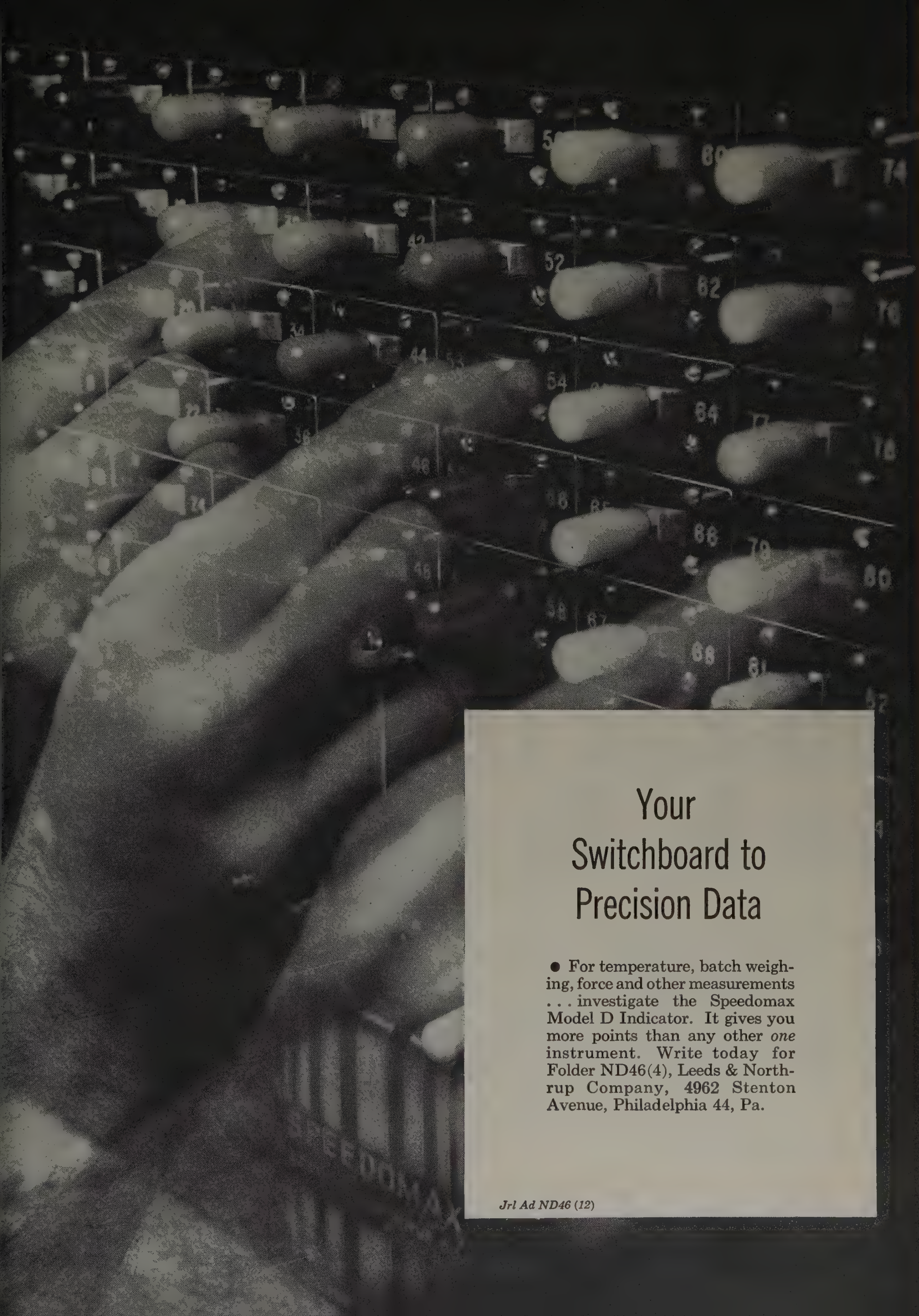
INSULATOR

This "special" Lapp insulator is a regular catalog item, and may be found on page 79 of the current Lapp Catalog No. Seven. It is regularly supplied, in considerable quantities, directly to power companies and through switch manufacturers. This particular combination, porcelain and attached caps, is a design now 27 years old, and it has performed with distinction, mechanically and electrically. For certain of your operating problems it may be a complete solution.

Beyond that, however, this particular insulator is of interest in the genealogy of electrical porcelain. Designed and first produced in 1926, it is the first unit of the now widely-used Lapp Post design. With characteristic fog-type leakage corrugations, it is a closed-end porcelain with integral top diaphragm, and sanded surfaces for outside bonding of metal caps. The Lapp Line Post and Station Post designs which followed a few years later were logical steps in the whole series of Lapp-pioneered improvements in operating characteristics of transmission and station insulators—and the resulting improved reliability of systems on which they are used. Lapp Insulator Co., Inc., Le Roy, N. Y.

Lapp



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Dependability Important

Installing a transformer in close quarters like this, places greater than usual importance on dependability. The rugged construction of Allis-Chalmers transformers, backed by most careful attention to manufacturing details, enabled them to measure up to the job. For example—a special bituminous compound gives added protection to surfaces and tubes in the base area. And spiral wound metallic gaskets give the best possible sealing for bushings. Welded covers, too, help eliminate future gasket maintenance.

Equally important is the location of transformer accessories, especially when working with limited dimensions. All of the accessories are located for convenient observation or operation.

More Details Available

There are many more reasons why it will pay to investigate the advantages of Allis-Chalmers network transformers. Get more details from your nearby Allis-Chalmers district office or write Allis-Chalmers, Milwaukee 1, Wisconsin.

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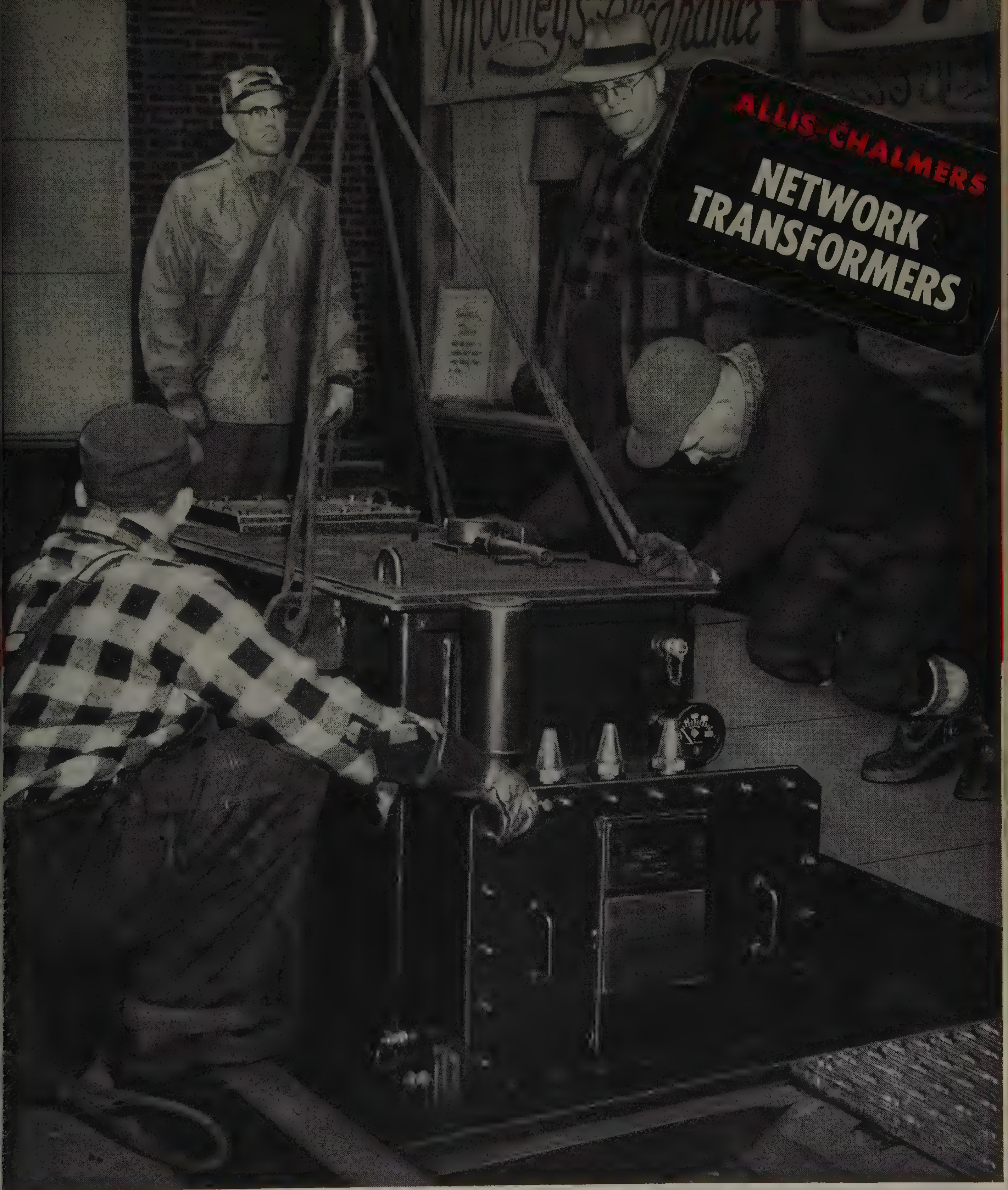

Here an Allis-Chalmers transformer is being installed at the corner of West Central Street and Hampshire Lane in Manchester, N. H. Neighborhood is an average growth area, but one where network reliability is extremely important. It includes stores, apartments, a school, and several restaurants. This 500-kva Allis-Chalmers transformer replaced a 50-kva transformer. The vault did not have to be enlarged.

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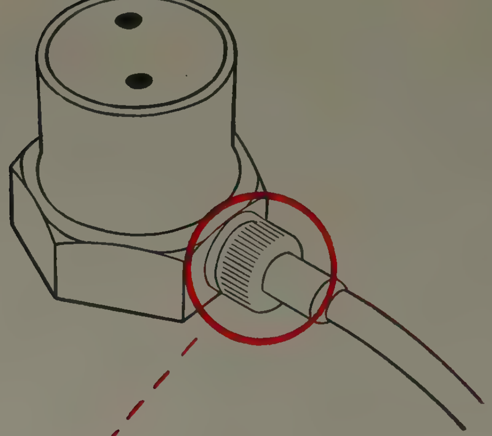

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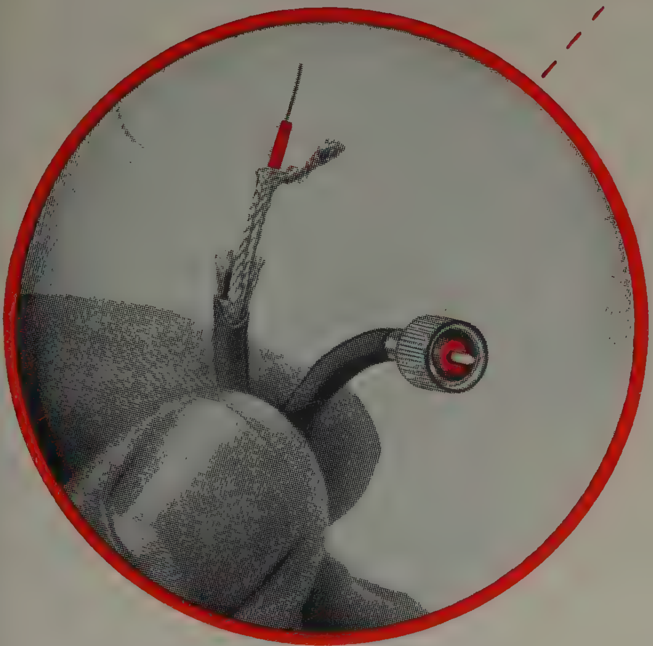

Coaxial connectors and cable made by Microdot Division, Felts Corporation, S. Pasadena, Calif.

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Du Pont "Teflon" serves many uses in electrical equipment—stand-off and feed-thru insulator terminals, insulation for wire, cables and motor windings, and other parts where high temperatures, dielectric strength and durability are required. Perhaps "Teflon" can help you improve or develop a product. For full information, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 2112T, Du Pont Bldg., Wilmington 98, Delaware.

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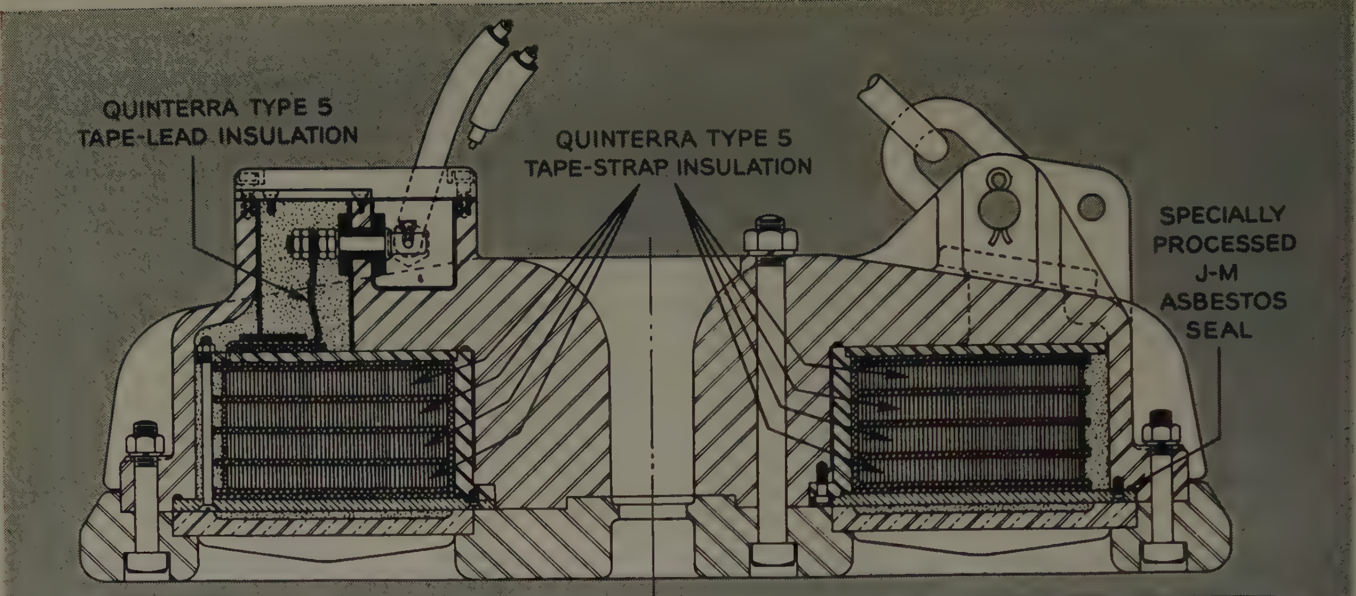

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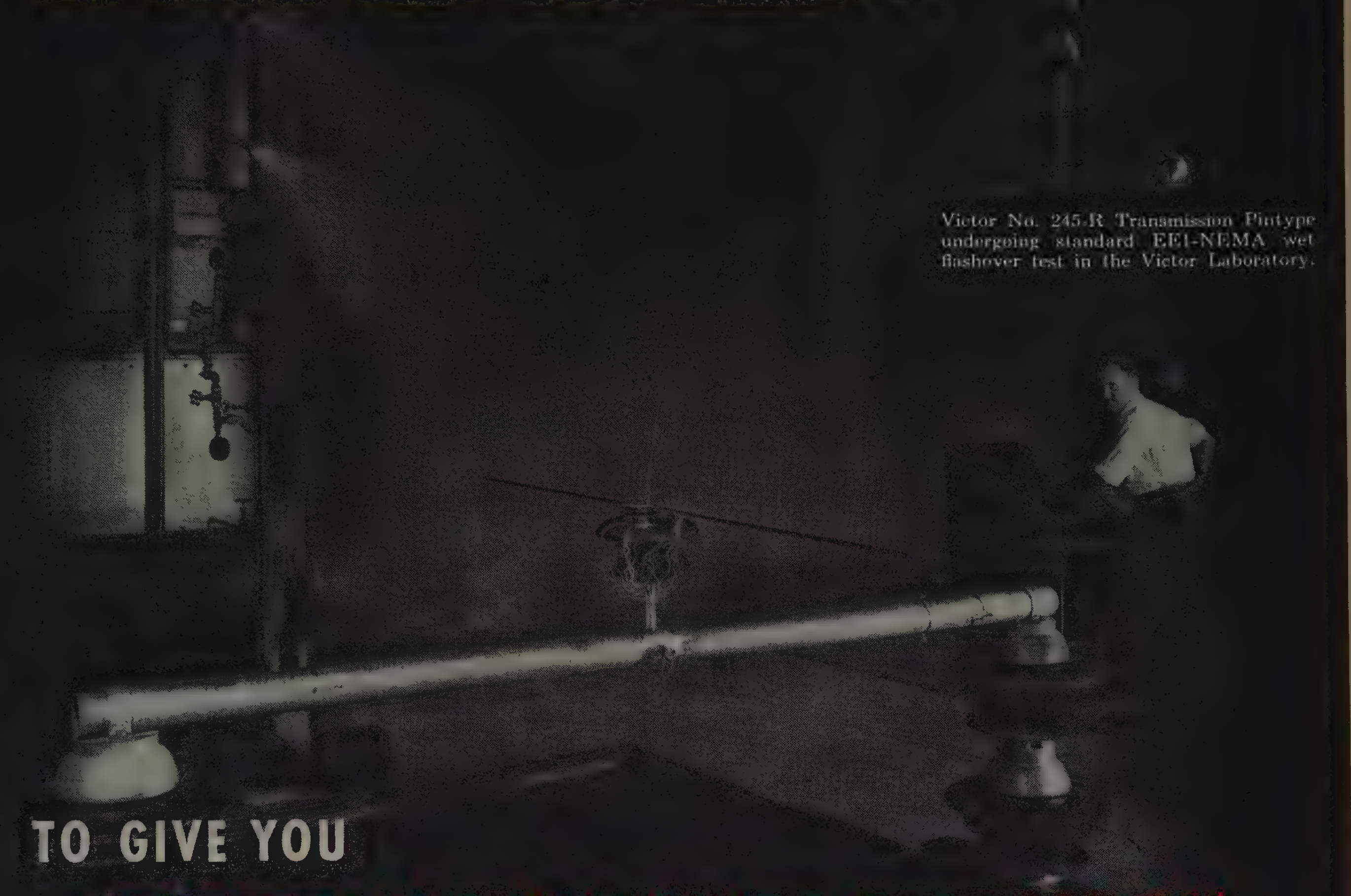

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Here are four typical transformer designs of Oil Burner Ignition Transformers, Television Transformers, Plastic Sealed Transformers and Hermetic Sealed Transformers.

Acme ACME Electric

Whether your need for transformers involve a household product, commercial installation or use by the military services, your best source of supply is Acme Electric.

Acme Electric is a thoroly trained organization, with experience to build special transformers in production quantities to high quality standards.

We have complete facilities to produce and test transformers covered by MIL-T-27 specifications.

TRANSFORMERS

ACME ELECTRIC CORPORATION
2212 WATER STREET • CUBA, N.Y.

Acme ACME Electric
TRANSFORMERS

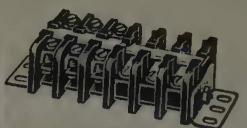
TYPE "FT"

TYPE "FTS"

CURTIS
TERMINAL BLOCKS
for —

- Experimental work (Build-up)
- Feed-thru applications
- High current requirements
- Control wiring
- Locked-in connections
- Combination terminals

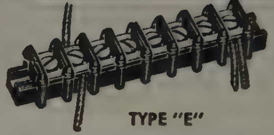
in —
Factory assembled and kit form
Tell us your terminal block problems
— for engineered recommendations



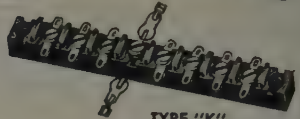
TYPE "BTH"

TYPE "H"

TYPE "BT"



TYPE "E"



TYPE "K"

TYPE "M"

TYPE "MT"

CURTIS DEVELOPMENT & MFG. CO.
3216 North 33rd Street, Milwaukee 16, Wisconsin

NEED A COMPLEX INSULATOR?

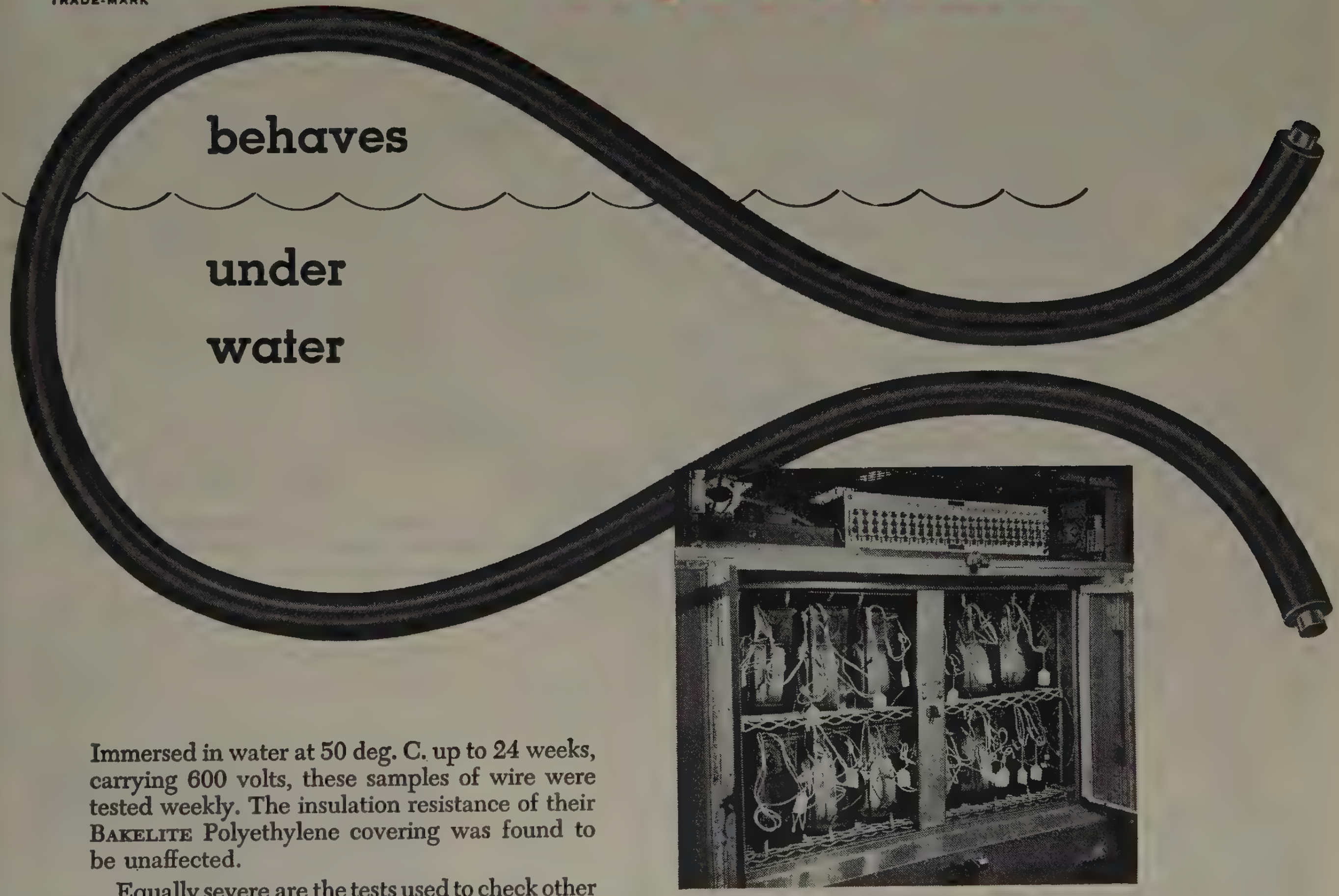
If you have an insulator design that looks like a Chinese puzzle, Universal can produce it for you in porcelain . . . with every detail meeting your exact specifications, every piece held to close tolerance and uniform body density.

Universal Porcelain combines high dielectric and physical strength . . . insulators are unaffected by hot arcing and thermal shock; resistant to temperatures, chemicals, moisture, fumes. Intricate or simple, long run or short, specify economical long-lifed Universal Porcelain Insulators on your next job.

THE UNIVERSAL CLAY PRODUCTS CO.
1560 EAST FIRST STREET
SANDUSKY, OHIO

How wire covering of BAKELITE Polyethylene behaves under water

TRADE-MARK



Immersed in water at 50 deg. C. up to 24 weeks, carrying 600 volts, these samples of wire were tested weekly. The insulation resistance of their Bakelite Polyethylene covering was found to be unaffected.

Equally severe are the tests used to check other physical and electrical properties of Bakelite Polyethylene. This remarkable line wire covering withstands abrasion, weathering, and chemicals. The approved black compound resists deformation up to 90 deg. C., stays flexible at temperatures as low as –70 deg. C. It meets ASA suggested specifications (second draft: July 20, 1952) for weather-resistant wire and cable.

Bakelite Polyethylene (black compound) has a specific gravity of only 0.94—lighter weight that means easier stringing. Its outstanding physical and electrical properties provide a thinner wire covering that speeds stripping and splicing. Its smooth waxlike finish helps in pulling over crossarms. Extruded over wire, a covering of Bakelite Polyethylene *won't festoon.*

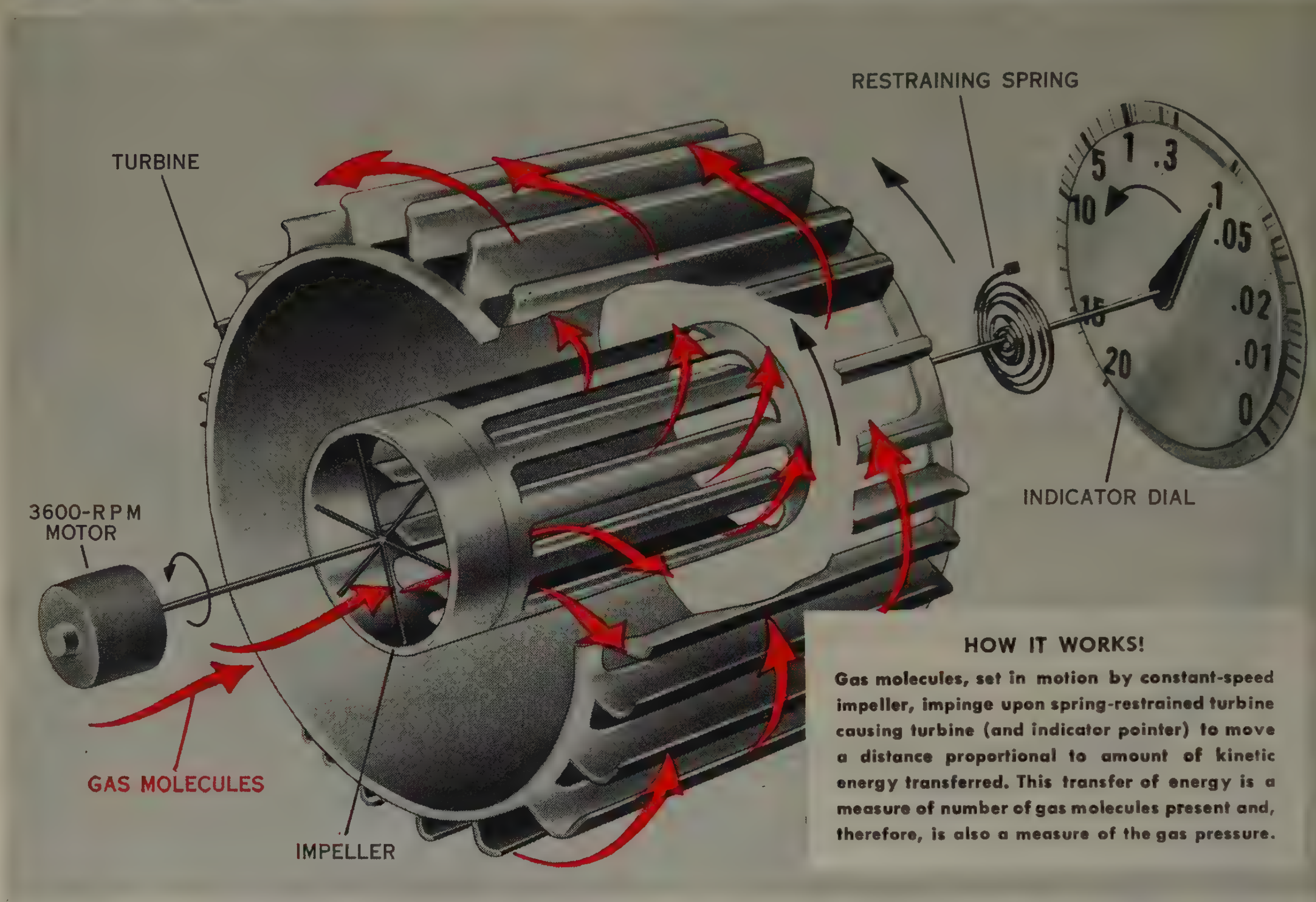
To learn about the properties of Bakelite Polyethylene in detail, get your free copy of Kabelitems No. 48. Write Dept. QZ-66.

OUTSTANDING ELECTRICAL PROPERTIES (black compound) for signal systems and service drop, wet or dry—at 50 megacycles and 25 deg. C., power factor is only 0.004; dielectric constant is 2.5. These values hold through the range from 60 cycles to 5 x 10^7 cycles. Operating temperatures up to 90 deg. C. have little effect on electrical properties. Insulation resistance is too high to measure on conventional testing devices. Bakelite Polyethylene excels in resistance to voltage breakdown, even after long-continued water immersion.

BAKELITE
TRADE-MARK
Polyethylene
WIRE COVERING

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N.Y.
In Canada: Bakelite Company (Canada) Ltd., Belleville, Ontario

LABORATORY INSTRUMENTS



HOW IT WORKS!

Gas molecules, set in motion by constant-speed impeller, impinge upon spring-restrained turbine causing turbine (and indicator pointer) to move a distance proportional to amount of kinetic energy transferred. This transfer of energy is a measure of number of gas molecules present and, therefore, is also a measure of the gas pressure.

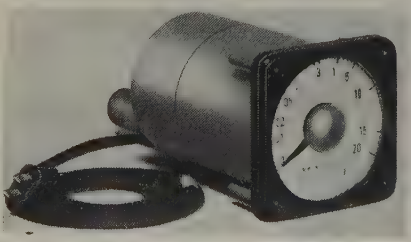
FOR SIMPLIFIED VACUUM MEASUREMENT—EASY OPERATION—EASY INSTALLATION . . .

G.E. Announces Revolutionary New Molecular Vacuum Gage

Similar to a "fluid clutch" in principle of operation, this new entirely mechanical molecular vacuum gage overcomes many of the problems encountered in the use of other type vacuum gages.

NO PRIMARY ELEMENT TO BURN OUT

Having no electronic tubes or other electrical detecting devices, the new G-E molecular vacuum gage assures continuous operation without time-consuming delays caused by electrical failure such as tube burnout.



New G-E gage is easy to mount, and its small size requires but a minimum of panel space.

UNHARMED BY ATMOSPHERIC PRESSURE

Because this new device may be opened to atmospheric pressure suddenly without damage to the instrument, it is especially valuable where personnel may be untrained in the use of complicated instruments.

SIMPLIFIED OPERATION

The new G-E molecular vacuum gage requires no complicated setting of control knobs. Direct-reading, the instrument calibration remains unaltered through continuous operation. The long-scale span in the high-vacuum range, and the easy-to-read indicator dial assure accurate readings.

HIGHLY VERSATILE

Available in two types, the molecular vacuum gage is supplied with a scale for the direct reading of dry air, or with a linear scale which may be calibrated for other gases. It is therefore suitable for laboratory and research installations as well as for many manufacturing and chemical processes. Price of the complete unit is $193.00.* For further information check coupon for Bulletin GEC-986.

FOR PRECISION MEASUREMENT

Costly Production Problems Easily Solved with the use of General Electric Oscillograph

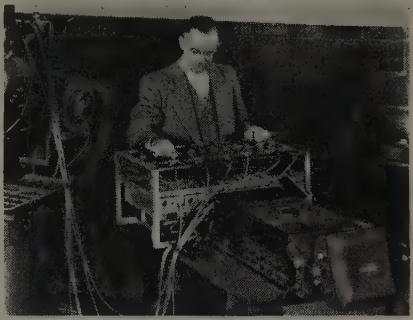
The United Shoe Machinery Corporation's research division gets the answers to timing and strain design problems by using General Electric PM-10 oscillographs.

PM-10 USED WITH STRAIN GAGES

A lever and cam system on their new Welt Butting and Tacking Machine, Model B, was breaking and causing high maintenance expense. In order to find the cause of the trouble, a six channel a-c strain gage amplifier was used in conjunction with a PM-10 oscillograph to record the strains while the machine was operating normally. The answers obtained enabled USMC engineers to quickly solve this important field service problem.

RECORDS MANY QUANTITIES

Designed to meet the wide field of applications for a twelve-element oscillograph, the Type PM-10 can be used to make simultaneous records of voltage, current, time, pressure, speed, stress, strain, sound, and vibration. Viewing while a record is being made is possible. Timing lines can be recorded directly on the film. Prices start at $4000.00* for the complete equipment. For more information check coupon for Bulletin GEC-449.



Studies with Type PM-10 oscillograph at United Shoe Machinery Corporation resulted in substantial savings in maintenance costs.

General Electric Oscillograph Aids Relay Manufacturer in Developmental Testing

Oscillograms in one minute was the answer recently when a large electrical manufacturer found it necessary to make some rapid development tests on a new type relay. The General Electric PM-18 oscillograph, equipped with a Polaroid-Land film holder, enabled the manufacturer to obtain permanent records of each test one minute after test, and to complete an entire series of eight tests in one hour.

Polaroid-Land film holder makes possible permanent records of each test with PM-18.

HIGH SENSITIVITY

The General Electric PM-18 oscillograph features a variety of highly sensitive galvanometers and adjustable time sweep of 0.1 to 0.5 seconds.

4 SIMULTANEOUS RECORDS

Designed to record two, three, or four currents or voltages simultaneously, the PM-18 can be used for sine-wave frequencies up to 500 cycles per second with its Polaroid-Land film holder and up to 2000 cycles per second with the continuous-drive film-holder attachment.

EASILY PORTABLE

Weighing only 30 pounds, the PM-18 can be readily carried to where it is needed. It is not necessary to bring the job to the oscillograph.

LOW COST

The General Electric PM-18 oscillograph, complete with Polaroid-Land film holder and two galvanometers costs only $850.59.* Check coupon for free Bulletin, GEC-580.

* Manufacturer's suggested retail price.

NEW...

1953 CATALOG

G-E Measuring Equipment

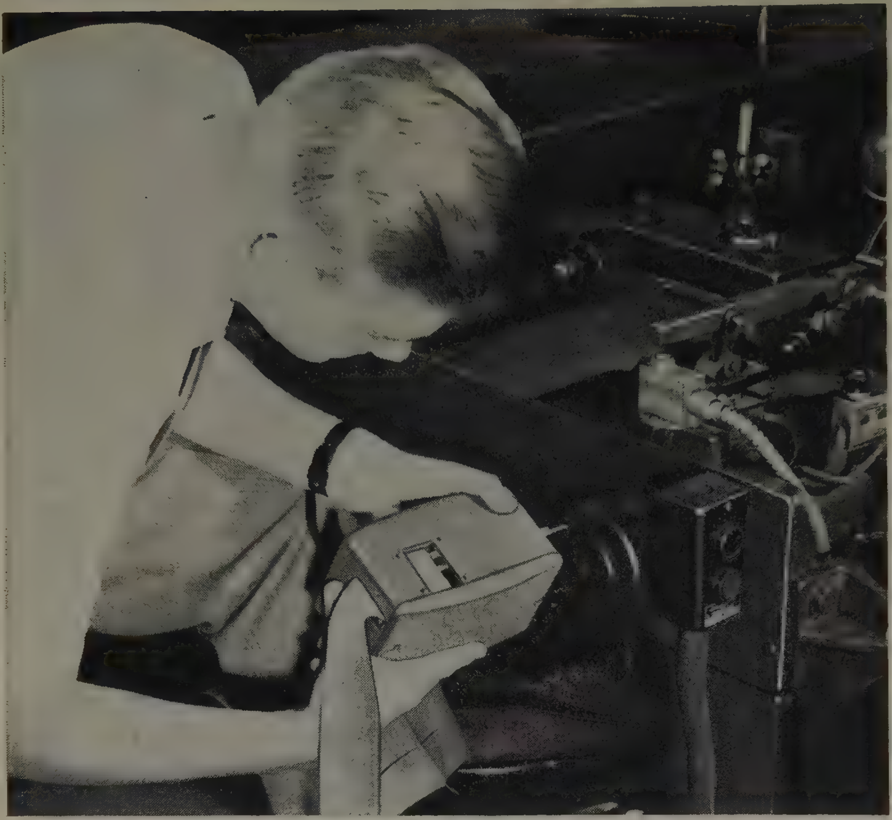
64 pages describing all of General Electric's testing and measuring devices. For free copy check GEC-1016A in coupon.

for coupon and more news about G-E Instruments SEE NEXT PAGE

You can put your confidence in—

GENERAL ELECTRIC

PRODUCTION INSTRUMENTS



G-E VIBROMETER RECORDS PUNCH-PRESS VIBRATION; GUARDS AGAINST BREAKDOWNS.

Vibrometer Price* Reduced 39%

Extremely versatile, General Electric's recording vibrometer is especially valuable in production testing, and installing and maintaining rotating equipment.

NEW LOW PRICE $265.20*

Because production-line manufacturing, necessitated by increased demand, has lowered production costs, General Electric now offers its portable recording vibrometer at only $265.20.*

HIGHLY VERSATILE

Two chart speeds are available; 1 inch per second, and 3 inches per second. The G-E recorder measures frequencies ranging from 10 cps to 120 cps, with a 0 to 20 G acceleration range. The vibrometer is accurate to within 5 per cent and measures amplitude from 5 to 125 mils.

EASY TO USE

The G-E recording vibrometer is particularly easy to operate. Because it makes a permanent record of vibration characteristics, accurate records can be kept of equipment that requires frequent inspection. Wave shape, frequency, and displacement of vibration is amplified and transferred to a waxed paper chart. This permanent record is then available for vibration analysis of the equipment.

CHECK COUPON FOR BULLETIN

Bulletin GEC-853 describes General Electric's complete line of vibration measuring equipment in detail.

Prevent Vibration Damage with Low-cost Portable Vibrometer

Areas of potential vibration damage in rotating machinery or buildings can be located immediately with this inexpensive G-E light-beam vibration indicator.

PORTABLE AND ACCURATE

Portability and high accuracy combined with no setup time are features which make the indicator ideal for production testing.

Simple, compact construction gives the light-beam vibrometer a long working life.

CONVENIENT TO USE

To use, you merely place the stylus of the instrument against the vibrating object and take a direct reading in mils. The length of the oscillating light's path indicates the peak-to-peak vibration displacement.

LONG LIFE

Simple construction gives this practical instrument a long working life. Only a few small moving parts are used. The battery is long-lived because the light beam switches off automatically when pressure is removed from the stylus.

LOW PRICE

Available with either of two scales—0–15 and 0–30 mils—the G-E light-beam vibrometer is accurate to within ±3% of full scale. Price $195.00.* Check coupon for Bulletin GEC-853.

GENERAL ELECTRIC

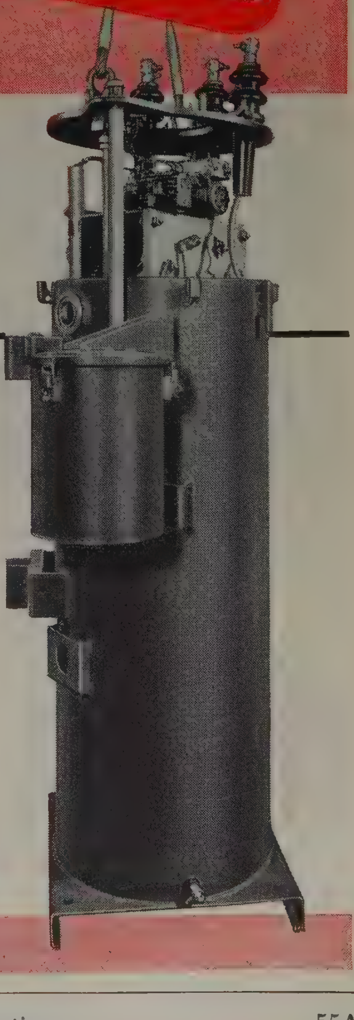
DISTRIBUTORS!

Distributor franchises are now available for many G-E instruments. For further information contact: Meter & Instrument Sales Department, General Electric Company, West Lynn, Massachusetts.

ALLIS-CHALMERS

5/8% STEP VOLTAGE REGULATORS

How a Regulator Adds Profits 2 Ways



1 **By Increasing System Revenue.** You get an accurate ± 1 volt band over 20% range of regulation when you apply Allis-Chalmers distribution regulators to your loads. No more trouble from low voltage during peak loads; maximum profits from your system at all times. Best of all, your customers are more satisfied — service calls due to low voltage can be practically eliminated.

2 **By Holding Future Service Costs to a Minimum.** Thanks to unit construction, you are assured of practically trouble-free operation with Allis-Chalmers distribution regulators. High quality workmanship is assured by constructing as an integral unit: bushings, cover, transformer, mechanism, and control. All connections are made and inspected *before* tanking. Same feature simplifies future inspection and maintenance by making untanking easy, permitting operation of regulators outside of tank without making special connections. For more facts, call your nearby A-C district office, or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-4106

RATINGS AVAILABLE	*7620 Volts—15, 50, 100 amp* *5000 Volts—50, 100 amp* *2500 Volts—100, 200 amp*

ALLIS-CHALMERS

Originators of 5/8% Step Regulation

"A shipyard is a graveyard we need top quality

says **INGALLS SHIPBUILDING COMPANY,**
world-famous shipbuilder, Pascagoula, Mississippi

At this vast shipyard, Ingalls has 1200 welding machines, and 1000 welders to man them. The Amerclad Welding Cable is run at top amperage 16 to 24 hours a day. It is dragged over razor-edged steel scrap and battered under heavy loads. It comes into contact with fresh welds while they are still red hot, and it is constantly showered with flaming slag from the burners' torches.

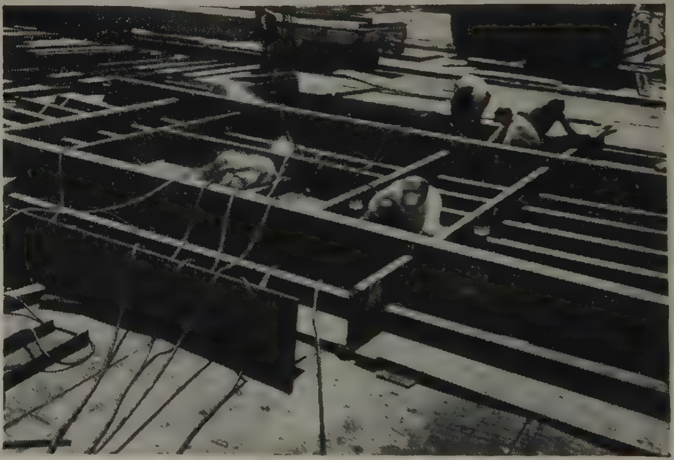
Mr. C. A. Guynn is the Master Mechanic at Ingalls in charge of all maintenance and service. He says this: "We're an all-welded shipbuilder, and we can't stand lost production time due to faulty cable. Our cable has to withstand heat and abuse, and it has to be *flexible*. An extra-flexible cable like Amerclad is easy on the welder's wrists, and it lasts *twice* as long as cables that lack this feature."

This great shipyard uses 60,000 feet of welding cable a year. But whether you use 60,000 feet or 600; whether you need a rugged cable for welding machines, power shovels or electric hand drills—there's a tough Amerclad design to give you the very best service life.

Send the coupon for more information about U·S·S Amerclad.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

Ingalls uses lots of Amerclad for portable power tools. Here, it powers a half-inch electric drill used to bore 6-inch shoring timbers.



This is a typical shipyard operating condition. The cable is exposed to all kinds of weather, and dragged over sharp steel plates and beams.

A STANDARD CABLE FOR

▼ asbestos wire and cable ▼ shovel & dredge cable
▼ paper & varnished cambric cable
▼ aerial, underground & submarine cable

AMERICAN STEEL & WIRE DIVISION
USS
AMERICAN ELECTRICAL WIRE AND CABLE
UNITED STATES STEEL

U·S·S AMERICAN ELECTRICAL

NEW STANDARDS

(Issued January 1953)

AUTOMATIC CIRCUIT RECLOSERS FOR A-C DISTRIBUTION SYSTEMS

No. 50

All single or multipole alternating-current automatic circuit reclosers for the nominal voltages from 1500 to 23,000 volts

Price: $.60; $.30 to AIEE members

◆

GUIDE FOR TEMPERATURE CORRELATION IN THE CONNECTION OF INSULATED WIRE AND CABLES TO ELECTRIC EQUIPMENT

No. 55

A general section which relates to the temperature correlation problem as a whole, as an aid in determining proper cable termination practice when making connections to electric equipment

Price: $.60; $.30 to AIEE members

◆

PREFERRED STANDARDS AND STANDARD SPECIFICATION DATA FOR LARGE 3600 RPM, 3-PHASE, 60-CYCLE CONDENSING STEAM TURBINE-GENERATORS

(Larger than 10,000 kw rated capacity)
AIEE No. 601-602; also ASME 100

Preferred standard ratings and characteristics of steam turbine-generators to simplify electric design work by establishing more nearly uniform specifications. General acceptance of these data should result in reduced prices and shorter deliveries than for non-standard machines

Price: $.60; $.30 to AIEE members

◆

TEST CODE FOR D-C AIRCRAFT MACHINES

No. 800

Defines uniformly acceptable methods of making tests to determine that the performance and other characteristics of d-c rotating machines for aircraft comply with specification and application requirements

Price: $.80; $.40 to AIEE members

◆

Order Department
American Institute of Electrical Engineers
33 W. 39th St., New York 18, N. Y.

Another Step in

Getting to the bottom of things

At John E. Fast and Co., the watchdogs of quality are on the job twenty-four hours a day, in every stage of capacitor production. Recording controls indicate the smallest variations in heat, humidity, pressure and vacuum at each process point. Every precaution is taken to assure that environmental conditions are held at precise levels specified by our engineers.

The air in our winding rooms, for example, is continuously filtered so that no foreign particles may settle upon the windings themselves and contribute to ultimate failures. Similarly, capacitors are assembled, after vacuum impregnation, in clean rooms, where relative humidity is controlled at all times. These safeguards against inclusion of extraneous matter or moisture have resulted in increasingly satisfactory life and allied performances in Fast capacitors.

Supplementing this automatic vigilance is a completely equipped quality-control organization which functions at every process-stage from incoming inspection to final testing. At points where statistical control is applicable, our inspectors utilize techniques which comply with or exceed specifications laid down by the Armed Services Procurement Branches.

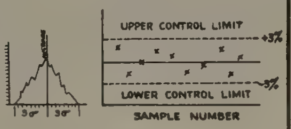
At final testing stations each production lot is given 100% test and inspection. Our belief is that a single failure out of a thousand may satisfy any sampling requirement, but it may be extremely costly to the consumer. Our investment in precision testing devices and extensive laboratory equipments is great, but its worth is reflected in our national reputation as producers of quality components.

Comprehensive reports are maintained by inspection centers located at strategic production points. These reports are summarized weekly, and it is quite significant to note that both the President of the Company and the Vice-President and Chief Engineer meet each Saturday morning with supervisors, engineers and military representatives to discuss the various problems indicated by process averages, and yield analyses for each production department.

In these days when every hour taken from the production job is spared grudgingly, we still take these hours every week to analyze and combat any threat to quality performance. Increasingly rigid specifications for dimensional and operational characteristics have shown very clearly that control of quality can be achieved and maintained only by rigorous application of all the techniques and tools we are employing.

No greater assurance of excellence may be given than that which has established our reputation. Our fixed objective will always be to maintain that reputation.

AVAILABLE LITERATURE:
Tubular Capacitors in paper tubes. 65° or 85°C rating SEC. I, CATALOG 25
Polystyrene Capacitors in paper tubes or metallic containers SEC. IV, CATALOG 25
Hermetically-sealed Tubular Capacitors SEC. VI, CATALOG 25
Subminiature Capacitors: Special Bulletin.
Jan C-25 Approved Capacitors: refer to Jan C-25, "Specifications"
Power-Factor Correction Capacitors SECS. I, II, III, IV, CATALOG 27

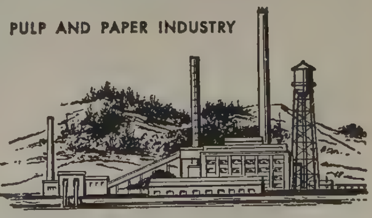


JOHN E. FAST & CO.
Capacitor Specialists For Over A Third of A Century
3169 North Pulaski Road, Chicago 41, Ill.
"WHEN YOU THINK OF CAPACITORS . THINK FAST"

Industry looks to
RESEARCH CORPORATION
for high dust collection efficiencies

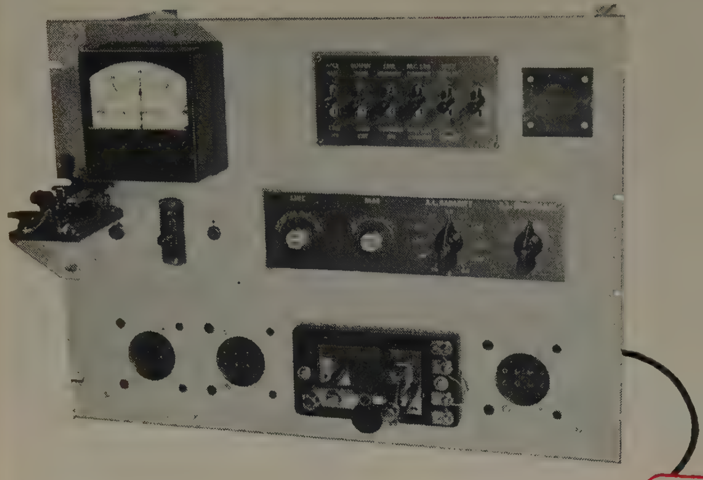
To maintain visually clean stacks at all times, industry is turning to the long experience of Research Corporation in the design and manufacture of highly efficient Cottrell Electrical Precipitators. We've spent 40 years in solving such problems as nuisance abatement, cleaning gas for subsequent use and recovering materials of value. Write for illustrated bulletin describing a wide range of electrical precipitator applications.

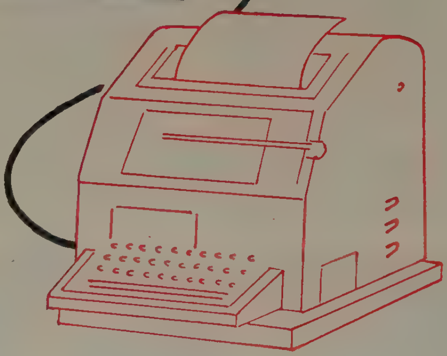
CHEMICAL PROCESS AND STEEL INDUSTRY



RESEARCH CORPORATION
405 Lexington Ave., New York 17, New York
122 South Michigan Ave., Chicago 3, Illinois
Bound Brook, N. J.

Specify the
PEC 369 DUPLEX REPEATER
for reliable teletype service





THE PEC 369 Duplex Repeater is especially designed to meet requirements of railroad teletype services and is widely used by many of the Nation's large railroads. It is compact, simply adjusted and easily maintained.

The PEC 369 Duplex Repeater uses the high speed circuit covered in AAR Spec 2K22 and provides a wide operating margin in teletype service. One of the outstanding advantages of this Duplex Set over other types, is the fact that all adjustments and checks of operating conditions can be made without the use of external equipment, since test keys, meter and morse key are all an integral part of the PEC 369 Duplex Repeater. In other words this Duplex Set includes its own test facilities.

The set is arranged for relay rack mounting, has an efficient rear dust cover and has an overall panel height of *only* 14 inches. Operating instructions on this Duplex Set should be of interest to all communications groups. Your copy will be sent to you upon request.

POWER EQUIPMENT *Company*

Battery Chargers ☆ Battery Eliminators ☆ D.C. Power Supply Units ☆ Regulated Exciters ☆ and other Special Communications Equipment

5740 NEVADA, EAST DETROIT 34, MICHIGAN

AIEE
REPORTS

These publications are proposals for new standards or test codes, or revisions of present publications, which are in the formative stage.

They are made available, without cost, so that all interested individuals may obtain them for study and comment, thereby supplying practical experience in their use before submission for adoption.

16A	Electric Control Apparatus for Land Transportation Vehicles (April 1951)
28A	Valve and Expulsion Type Lightning Arresters (February 1950)
51	Guiding Principles for Dielectric Tests (September 1949)
52	Application Guide for Grounding of Instrument Transformer Secondary Circuits and Cases (March 1951)
53	Proposed Guide for Operation and Maintenance of Dry Type Transformers with Class B Insulation (October 1952)
54	Standard, Test Code, Recommended Practice for Induction and Dielectric Heating Equipment (October 1952)
502	Test Code for Single-Phase Motors (November 1941)
504	Test Code for Carbon Brushes (October 1953)
801	Test Code for Aircraft Interrupting Devices (August 1950)

No charge for copies

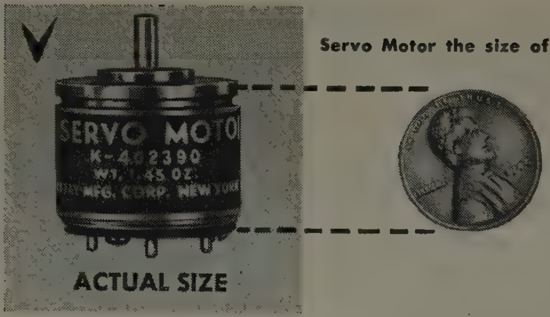
American Institute of
Electrical Engineers
33 West 39th St., New York 18

12-53

TYPICAL CHARACTERISTICS

MECHANICAL DATA		ELECTRICAL DATA	
Weight	1.45 oz.	No load speed	6,500 RPM
Rotor inertia	.46 gm-cm^2	Stall torque	.3 oz.-in.
Theoretical acceleration	49,000 RAD/SEC^2	Maximum output	.490 W.
		Single phasing	None

DATA AT STALL	FIXED PHASE	CONTROL PHASE
Voltage (volts)	26	26
Frequency (cycles)	400	400
Current (ma.)	166	166
Power imput (watts)	3.1	3.1
Power factor	.63	.63
R—ohms	98.5	98.5
X—ohms	123	123
Z—ohms	157	157

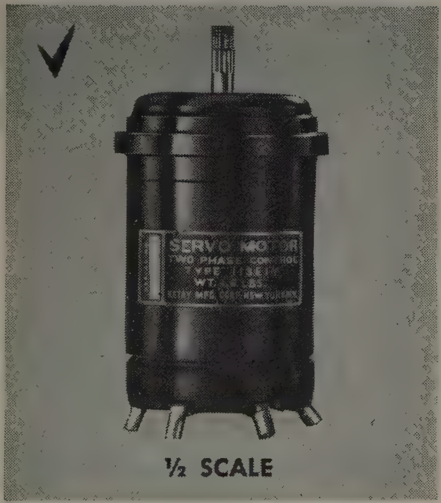


Servo Motor the size of a Penny

ACTUAL SIZE

Ketay's Experience helps you

Servo Motor in a size 23 Frame, 6 watt



½ SCALE

TYPICAL CHARACTERISTICS

MECHANICAL DATA		ELECTRICAL DATA	
Weight	1.6 lbs.	No load speed	3,500 RPM
Rotor inertia	20.0 gm-cm^2	Stall torque	7.5 oz.-in.
Theoretical acceleration	26,500 RAD/SEC^2	Maximum output	6.0 W.
		Single phasing	None

DATA AT STALL	FIXED PHASE	CONTROL PHASE Series	CONTROL PHASE Parallel
Voltage (volts)	115	115	57.5
Frequency (cycles)	60	60	60
Current (ma.)	175	175	350
Power imput (watts)	14.0	14.0	14.0
Power factor	0.70	0.70	0.70
R—ohms	460	460	115
X—ohms	470	470	117
Z—ohms	660	660	164

Also for 115V or 230V operation on control phase.

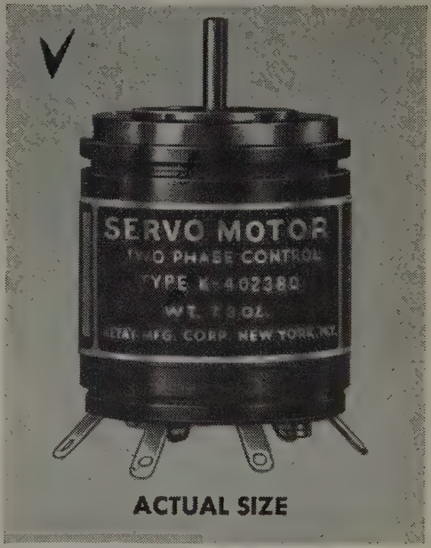
Check these Servo Motors against your needs

Ketay offers a complete line of high precision **SYNCHROS, SERVO MOTORS and RESOLVERS.**

Ketay's experience also includes: automatic control devices for use in fire control and missile systems; computers and simulators; amplifiers; marine inter-communication equipment; remote indicators such as ship course indicators, drive angle indicators and salinity indicators; and automatic control systems.

Mail coupon today for bulletin containing specifications on 100 types of Synchros, Servo Motors and Resolvers.

Servo Motor in a size 15 Frame, 60 cycle, 115 volt



ACTUAL SIZE

TYPICAL CHARACTERISTICS

MECHANICAL DATA		ELECTRICAL DATA	
Weight	7.3 oz.	No load speed	3,300 RPM
Rotor inertia	3.03 gm-cm^2	Stall torque	1.45 oz.-in.
Theoretical acceleration	33,800 RAD/SEC^2	Maximum output	1.23 W.
		Single phasing	None

DATA AT STALL	FIXED PHASE	CONTROL PHASE Series	CONTROL PHASE Parallel
Voltage (volts)	115	115	57.5
Frequency (cycles)	60	60	60
Current (ma.)	53	53	106
Power imput (watts)	5.0	5.0	5.0
Power factor	.82	.82	.82
R—ohms	1780	1780	445
X—ohms	1240	1240	310
Z—ohms	2170	2170	542

Ketay

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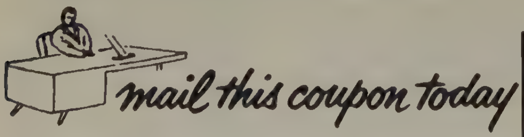
Any way you look at it, money invested in silicone (Class H) insulation pays handsome dividends in lower maintenance costs, more continuous production, greater capacity, lower motor inventory costs. And now is the time to capitalize on it.



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- ☐ List of Class H motor repair shops.
- ☐ Data on Silicone Grease for motor bearings.
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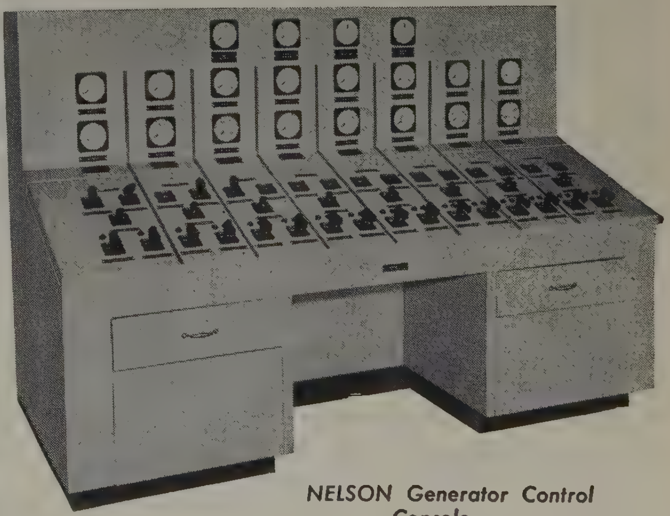

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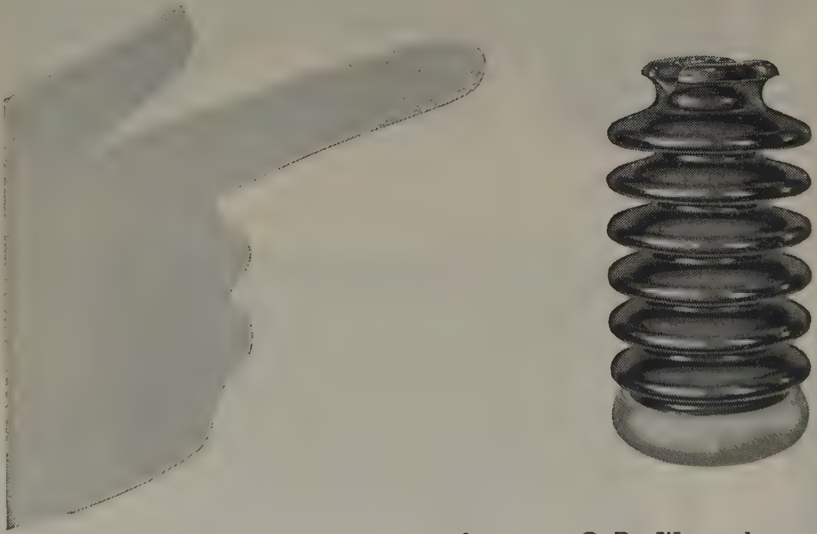

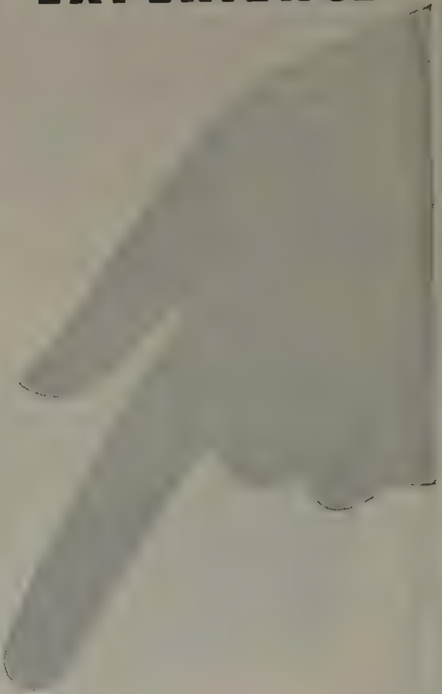

We make pintype and post insulators at O-B. We make them both as well as we know how, and improve them whenever our experience shows where improvements can be made. Thus there is no need for us to make comparisons between posts and pintypes, which may be misleading, and we do not recommend one over the other. Over a long, long time in the insulator business, we've learned that the right type on one line may not be the best choice for another. That choice is best made on the basis of user experience. Service records provide a fine guide to the selection of proper insulator types.

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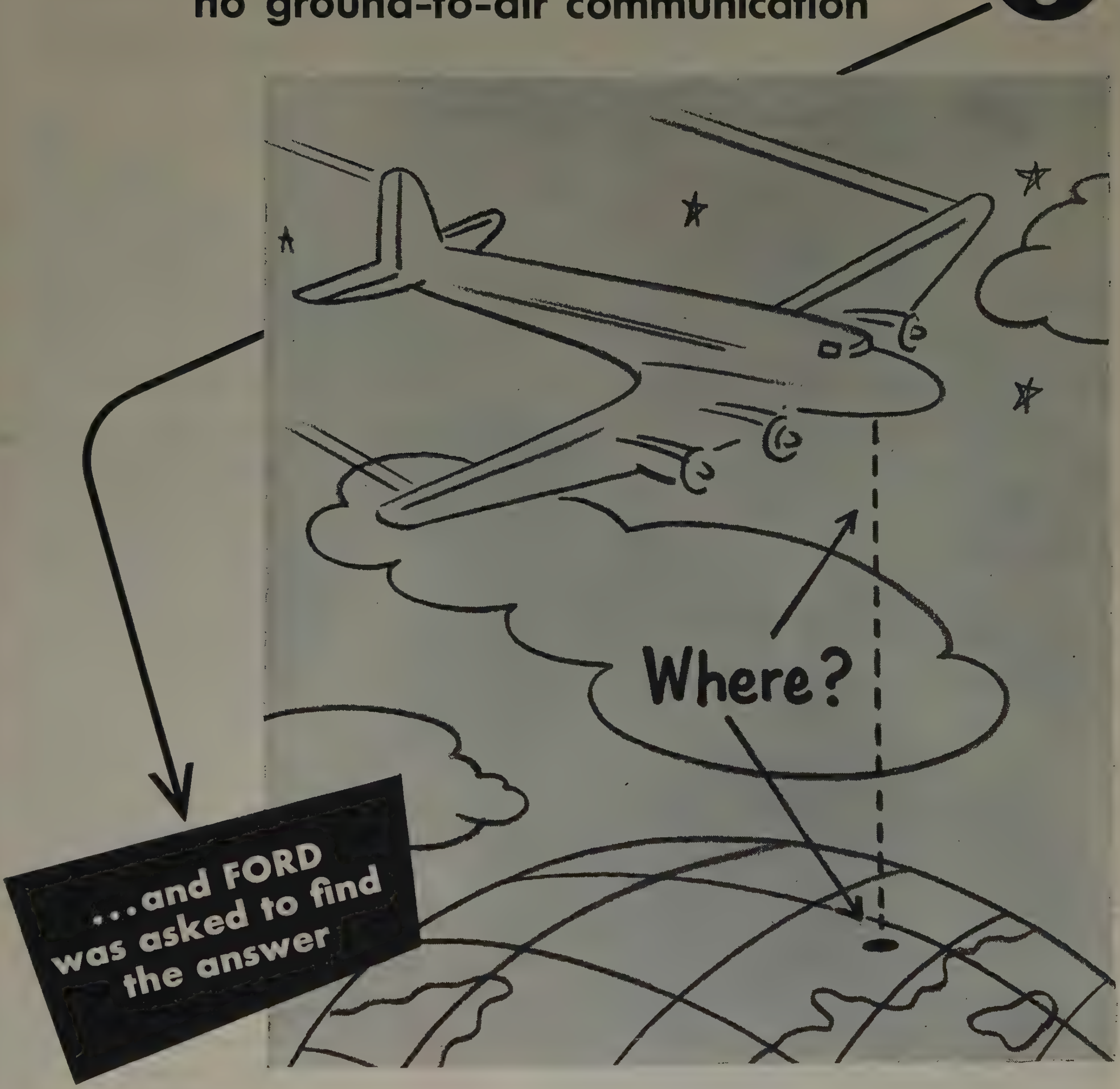
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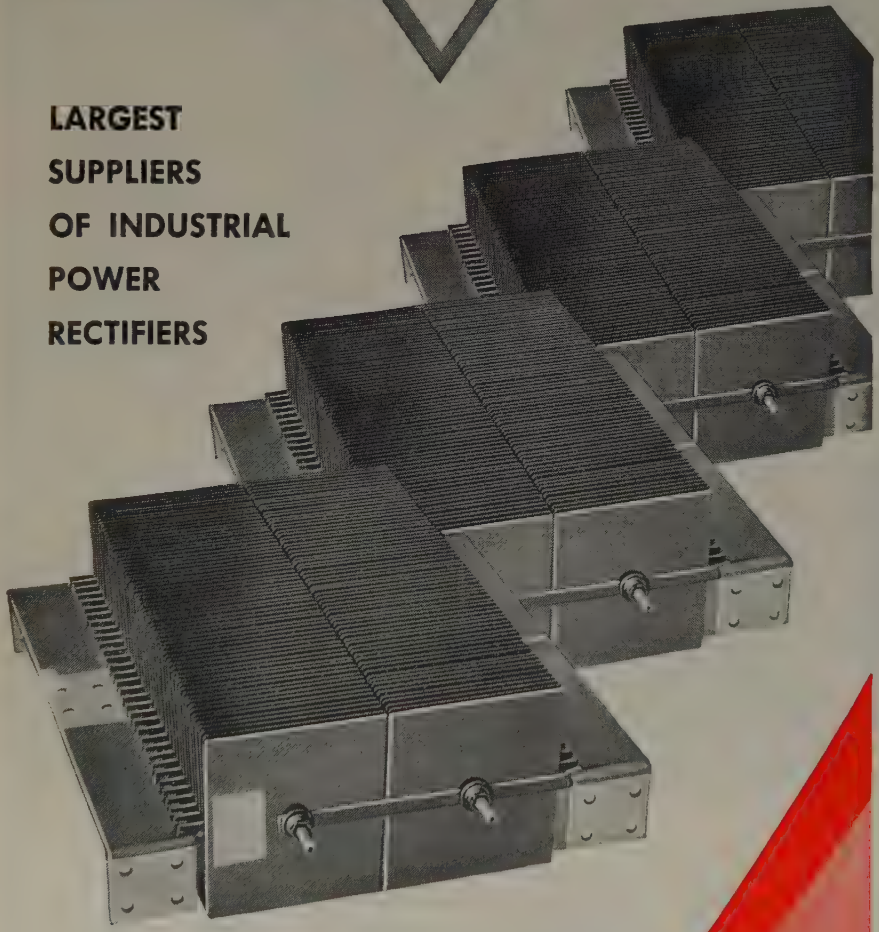

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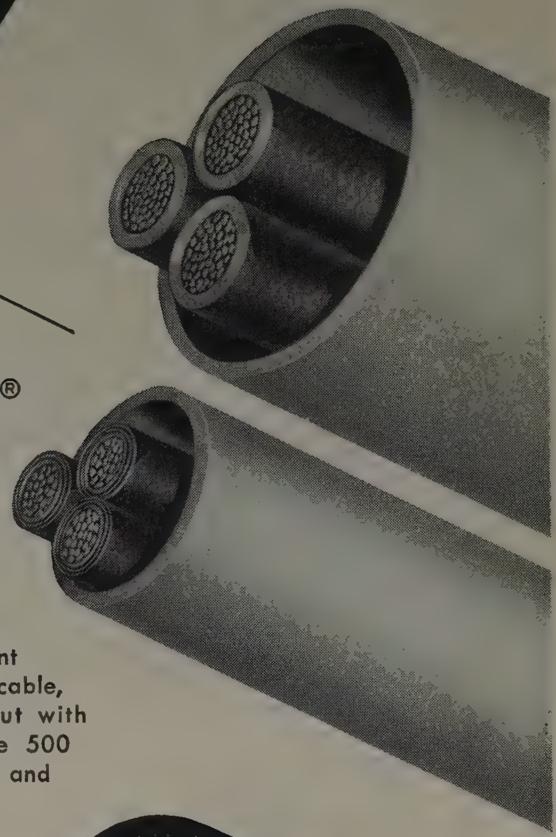

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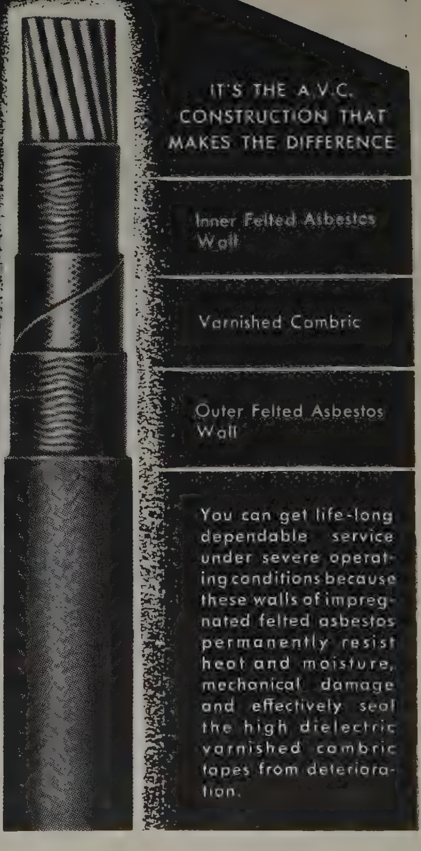
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Watching the serenity of Christmas skies, we are conscious of deep silence. Yet the stars are talking to us all the while—talking in radio waves that are full of meaning to scientists probing the depths of space.

The important discovery that some stars produce radio waves was made by a Bell Laboratories scientist while exploring atmospheric disturbances which might interfere with transoceanic telephone service.

His discovery marked the birth of the fast-growing science of radio astronomy. It is telling us of mysterious lightless stars that broadcast radio waves, and it promises new and exciting revelations about the vast regions of space concealed by clouds of cosmic dust.

Directional radio antenna used by Karl G. Jansky, in the discovery of stellar radio signals at the Holmdel, New Jersey, branch of Bell Telephone Laboratories. In 1932 he detected waves of 14.6 meters coming from the direction of Sagittarius in the Milky Way.

It is another example of how Bell Telephone Laboratories scientists make broad and important discoveries as they seek ways to make your telephone serve you better.

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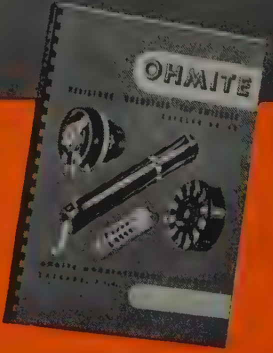

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Swedish Steel Cored Aluminium Conductors

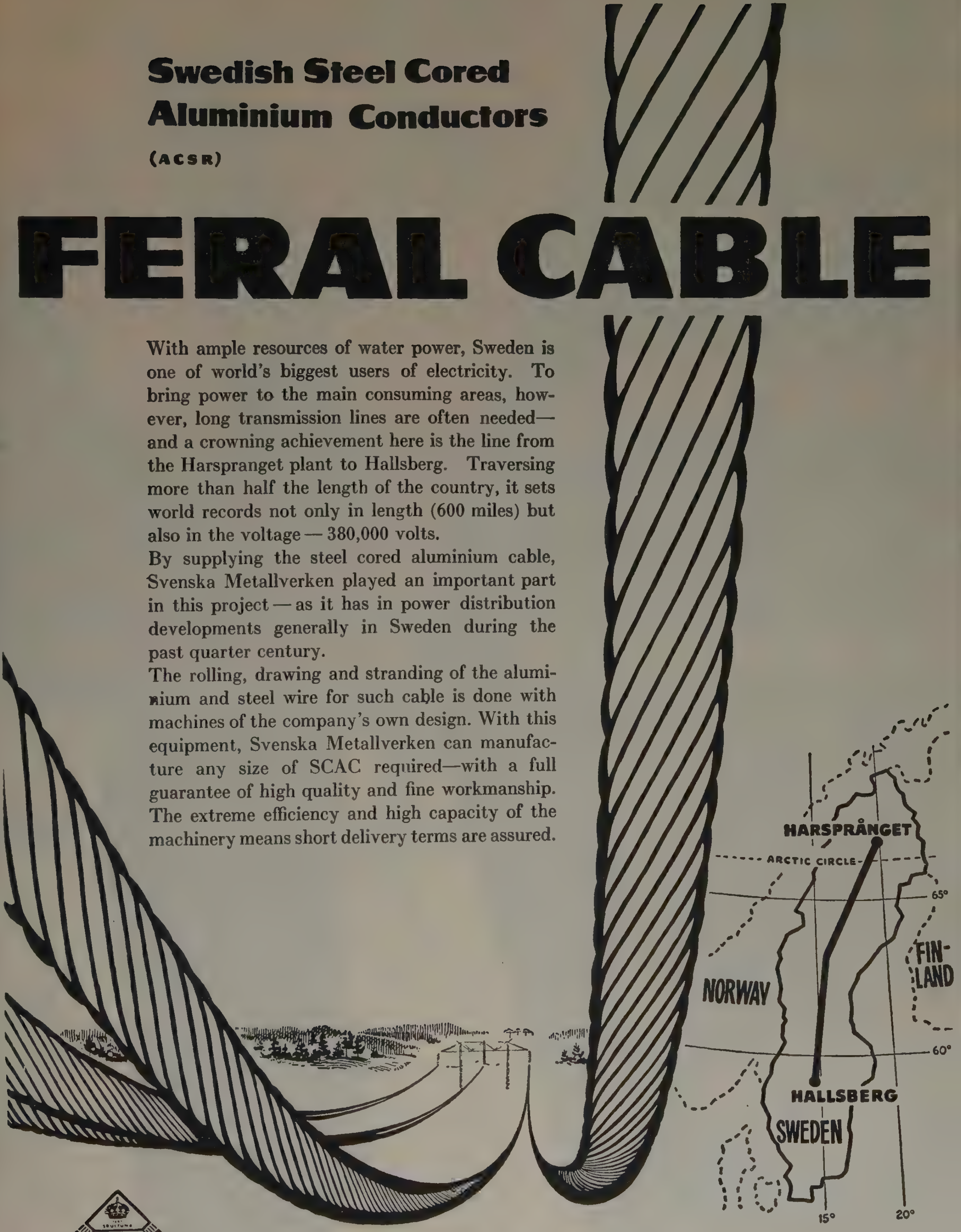
(ACSR)

FERAL CABLE

With ample resources of water power, Sweden is one of world's biggest users of electricity. To bring power to the main consuming areas, however, long transmission lines are often needed—and a crowning achievement here is the line from the Harspranget plant to Hallsberg. Traversing more than half the length of the country, it sets world records not only in length (600 miles) but also in the voltage — 380,000 volts.

By supplying the steel cored aluminium cable, Svenska Metallverken played an important part in this project — as it has in power distribution developments generally in Sweden during the past quarter century.

The rolling, drawing and stranding of the aluminium and steel wire for such cable is done with machines of the company's own design. With this equipment, Svenska Metallverken can manufacture any size of SCAC required—with a full guarantee of high quality and fine workmanship. The extreme efficiency and high capacity of the machinery means short delivery terms are assured.



The world's longest power transmission line, with a tension of 380,000 volts, from Harspranget to Hallsberg in Sweden, has six Feral Cables.

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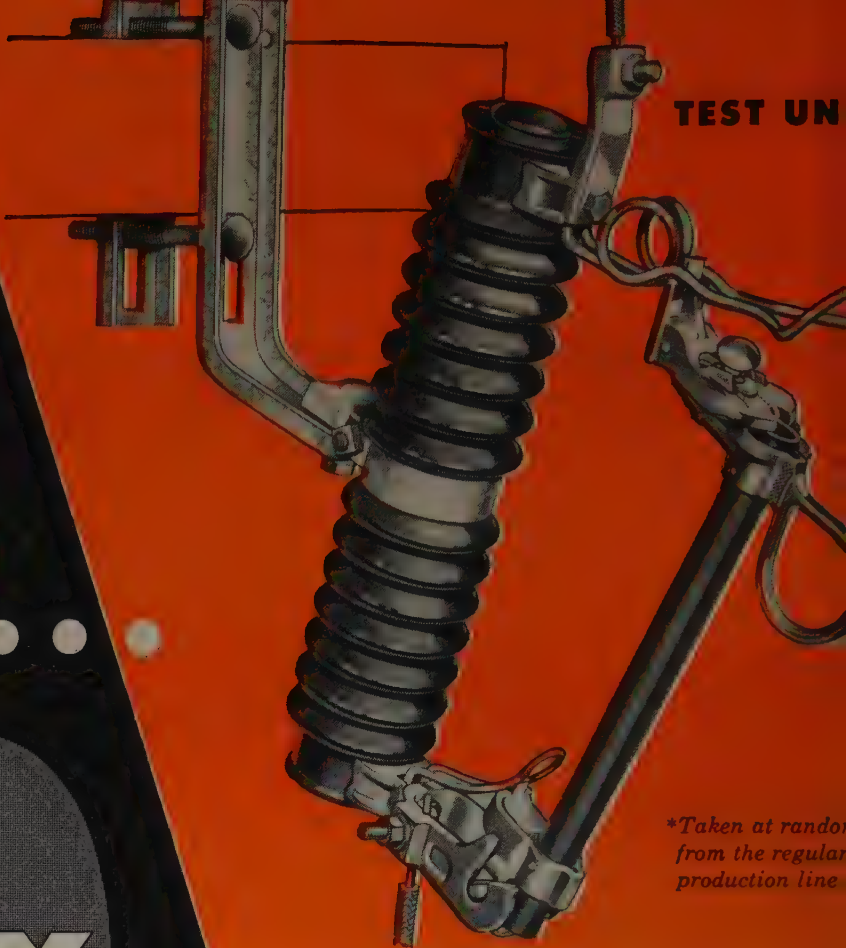

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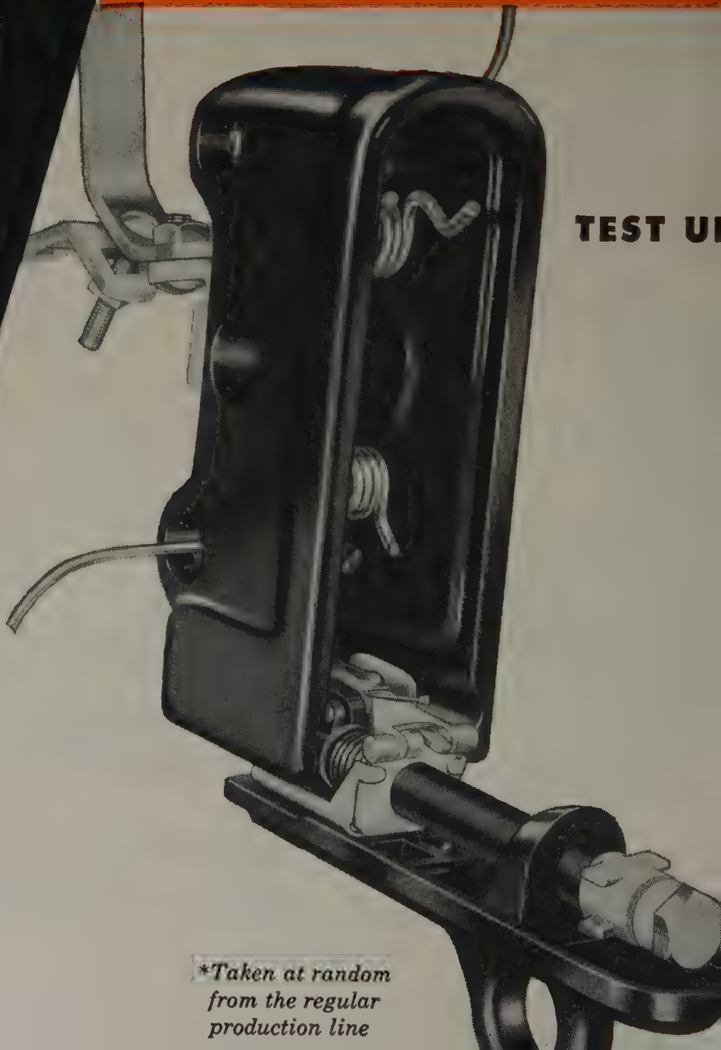

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HD rd HEAVY DUTY TRIP-OUT

16234-3

TEST DATA

Voltage 14,400 KV; Power Factor 20%; X/R=4.88

Cutout Cat. No.	Test No.	Current Amperes RMS	Clearing Time Cycles	Kearney Fuse Link	
				Rating	Type
16234–3	1	8050	½+	80	200-U
100 Amp.	2	7620	½+	80	200-U
15 KV	3	8750	½+	80	200-U
	4	8320	½+	80	200-U
	5	8750	½+	100	200-U
	6	7900	2½	100	KS-U

RATING: 100 amperes, 15 KV.

RESULTS: At 14.4 KV with a power factor of 20%, the cutout sucessfully interrupted six shots ranging from 7620 to 8750 amperes, RMS. After the sixth shot both the cartridge and contacts were carefully examined and found to be in perfect working condition.

After the short circuit test, without adjustment of any kind, the cutout was tested for temperature rise. The maximum was 13° C, as compared to 30° allowable by NEMA for new cutouts.

ACTUAL TEST DATA on Short Circuit Interruption PROVES KEARNEY HEAVY DUTY Cutouts Have Ample Interrupting Capacity for Today's Heavy Loads

HD rd HEAVY DUTY TRIP-O-MATIC

indicating 12143-20
non-indicating 12143-21

TEST DATA

Voltage: 5046; Power Factor: 20%; X/R=4.88

Cutout Cat. No.	Test No.	Current Amperes RMS	Clearing Time Cycles	Kearney Fuse Link	
				Rating	Type
12143-20 100 Ampere 5 KV Indicating	1	7250	1	50	KS
	2	7680	1	80	200
	3	6620	1	80	200
	4	6200	1½	80	200
	5	7850	1	100	200
	6	6400	1½	100	200
	7	6600	1	100	200
	8	6200	1½	100	200
	9	7250	1	100	200
12143-20 (original box) (with new door)	1	6600	1	100	200
	2	6880	1	100	200
	3	7050	1½	100	200
12143-21 100 Ampere 5 KV Non-Indicating	1	2900	1½	50	200
	2	4250	2½	100	200
	3	7850	1	50	KS
	4	6750	1	50	KS

RATING: 100 ampere, 5 KV.

RESULTS: At 5 KV with a power factor of 20%, the indicating Trip-O-Matic successfully interrupted nine shots ranging from 5500 to 6350 amperes, RMS, at 5046 volts. Then three additional tests were made on the same box with a new door installed. 5800, 5750 and 6050 amperes were successfully interrupted. The non-indicating Trip-O-Matic successfully interrupted four shots ranging from 2800 to 6000.

After the short circuit tests, a heat run was made on the same non-indicating box. Maximum temperature rise was found to be 21° C, as compared to 30° allowable by NEMA for new cutouts.

TEST SET-UP: This circuit interruption data is *not based on calculation*. It is the result of actual field tests at Kearney's 34.5 KV substation. Power was taken from the Union Electric circuit providing a 445,000 KVA back-up. In the Heavy Duty Trip-Out tests, faults were made on the 15 KV side of a 10,000 KVA transformer. In the Heavy Duty Trip-O-Matic tests, faults were made on the 5 KV side of the same transformer.

These test results are proof-positive that Kearney cutouts protect your circuits with *even greater* capacity than their normal ratings.

JAMES R.
KEARNEY
CORPORATION
ST. LOUIS, MO

"My brushes are giving me trouble, doc—how about giving me the Stackpole treatment?"

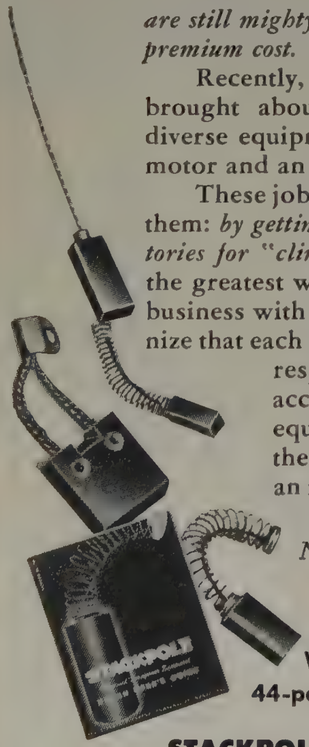
Small Motor Brush Clinic

...for longer life, greater efficiency

No doubt, you're getting pretty good brush life and performance on small motor applications these days. *But, chances are still mighty good that they can be materially improved—at no premium cost.*

Recently, for instance, Stackpole brush developments brought about worthwhile improvement on such widely diverse equipment as toy trains, a coal drill, a d-c gas pump motor and an ac-dc inverter.

These jobs were handled the way Stackpole likes to handle them: *by getting the actual motorized equipment into our laboratories for "clinical" test.* Here, Stackpole engineers combine the greatest wealth of small motor brush "know how" in the business with carefully planned experimentation. They recognize that each brush application differs from others in essential respects. These peculiarities are taken into full account in developing grades exactly suited for the equipment in question. And, more often than not, they come up with a brush recommendation that is an improvement over what has been used in the past.



NOTE: Stackpole brushes are sold only to manufacturers of original equipment.

Write on company stationery for the 44-page Stackpole BRUSH USERS' GUIDE.

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This report on a recommended practice reviews the theoretical aspects of the interference problem and then outlines procedures which should be followed; which may be applied both in construction and as remedial measures where interference exceeds limits specified in FCC rules. Price $.80; 50 per cent discount to AIEE members. Address:

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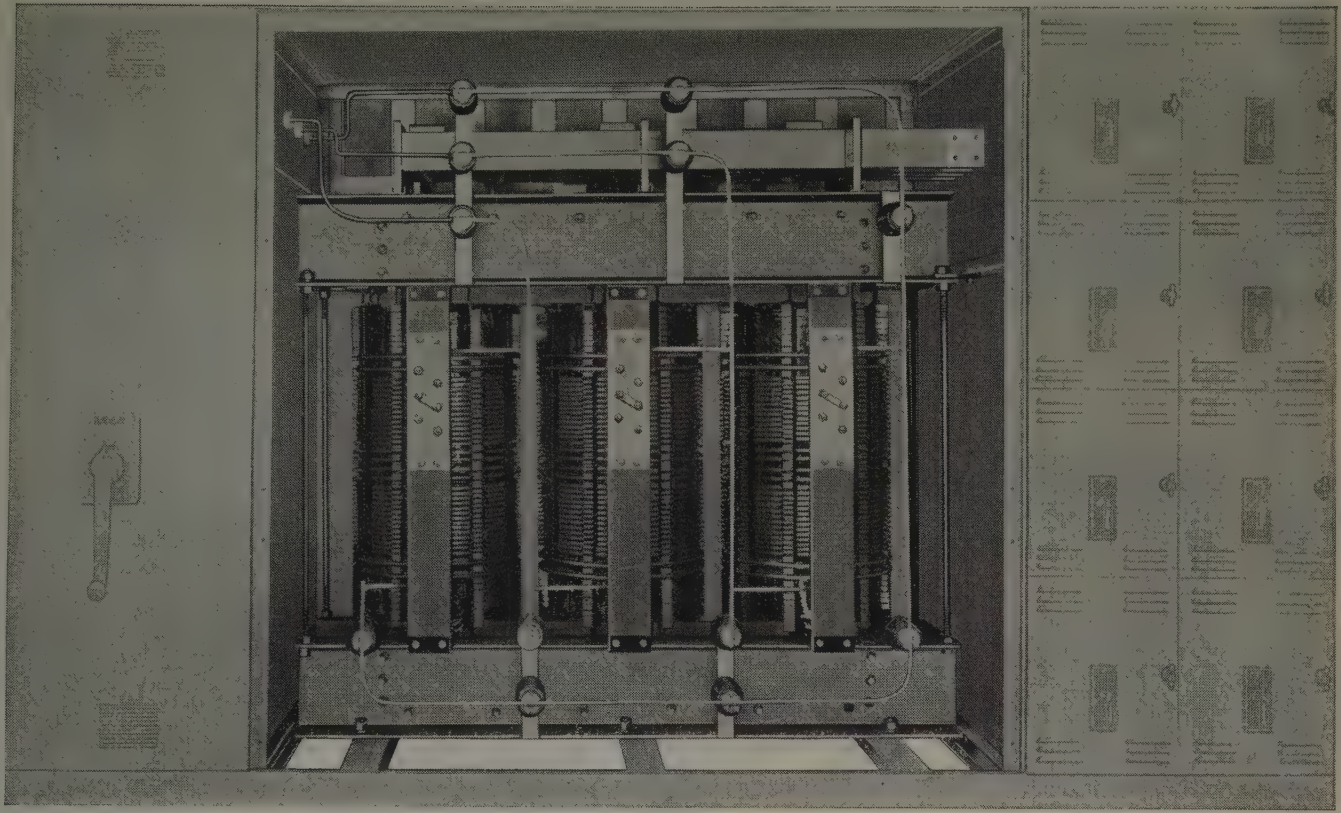
12-53

The transformer is the heart of a substation



1000 Kva 13,200 volt substation—with transformer compartment panel removed

A substation is no better than its transformer; therefore, it is important that the transformer is of the best quality—a Sorgel air-cooled dry-type transformer.

Dry-type transformers are the most practical type for indoor installations. They require little or no maintenance; no liquid to check or replenish; no fire hazard; small and compact; economical; easy and convenient to install; no vault required; can be placed close to load center, resulting in better voltage regulation. Easily moved when required for expansion or alterations.

Sorgel air-cooled dry-type transformers are top quality, time tested, and are thus recognized and accepted by discriminating engineers and users. Their rugged construction assures continuous, reliable service. Liberal design. High efficiency. Low noise level.

The Sorgel Electric Co. has had over 35 years of experience in the development, manufacturing and application of dry-type transformers.

Sorgel air-cooled transformers are procurable with any make of switch gear, and from any substation manufacturer.

¼ Kva to 3000 Kva.

All voltages
120 to 15,000 volts

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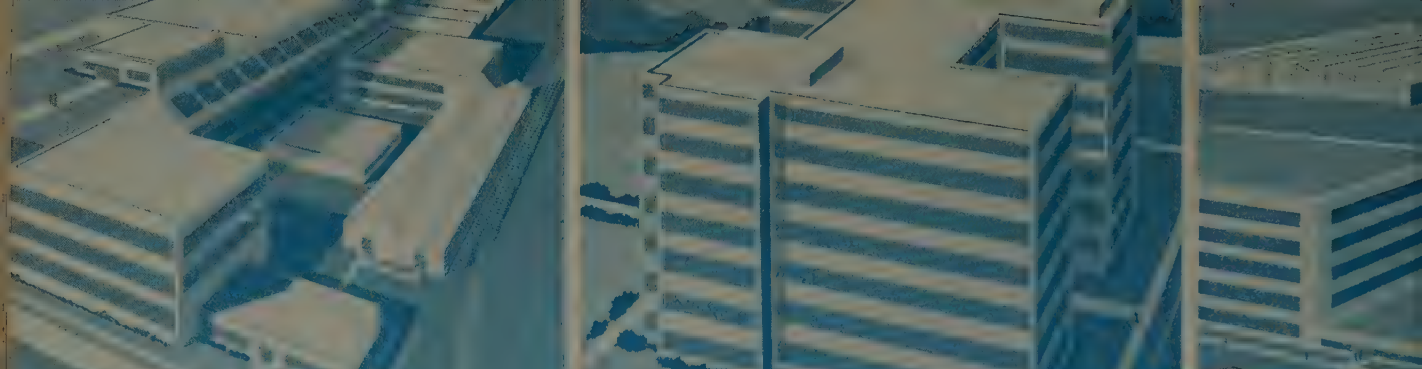

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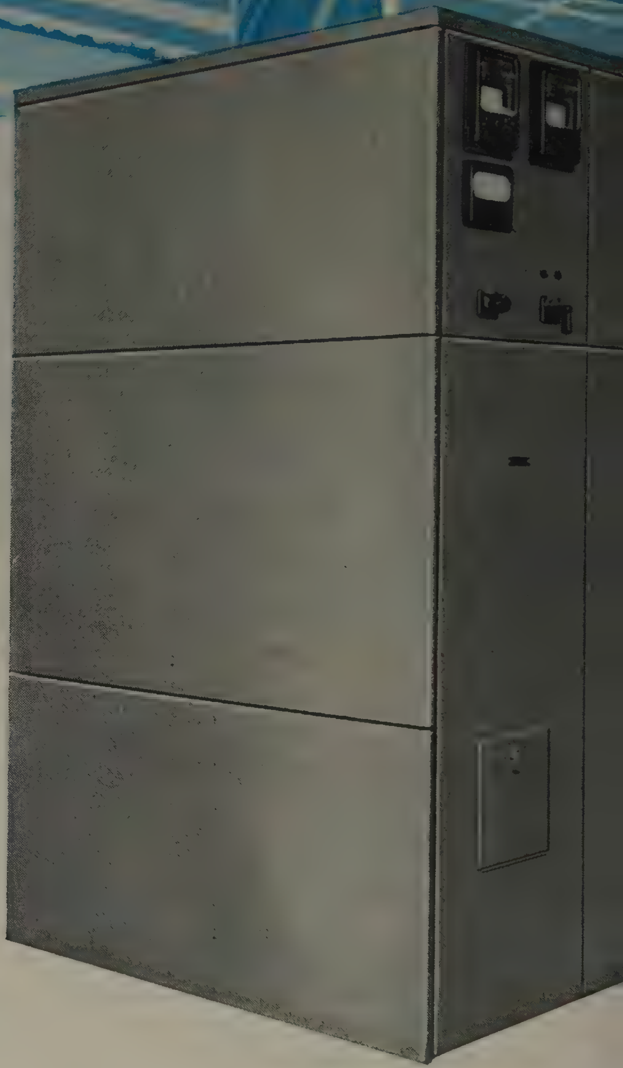

unit substations are basic plant investments

In central stations, industrial plants, or buildings—engineering management recognizes the need for power distribution equipment which is safe, dependable, economical, and adaptable. To Unit Substations, forming the *nerve centers* of any distribution system, is delegated the important responsibility of providing continuous power and circuit protection for years to come. Unit Substations, therefore, should not be merely *adequate*, but they must have quality to be a sound, *profitable* capital investment.

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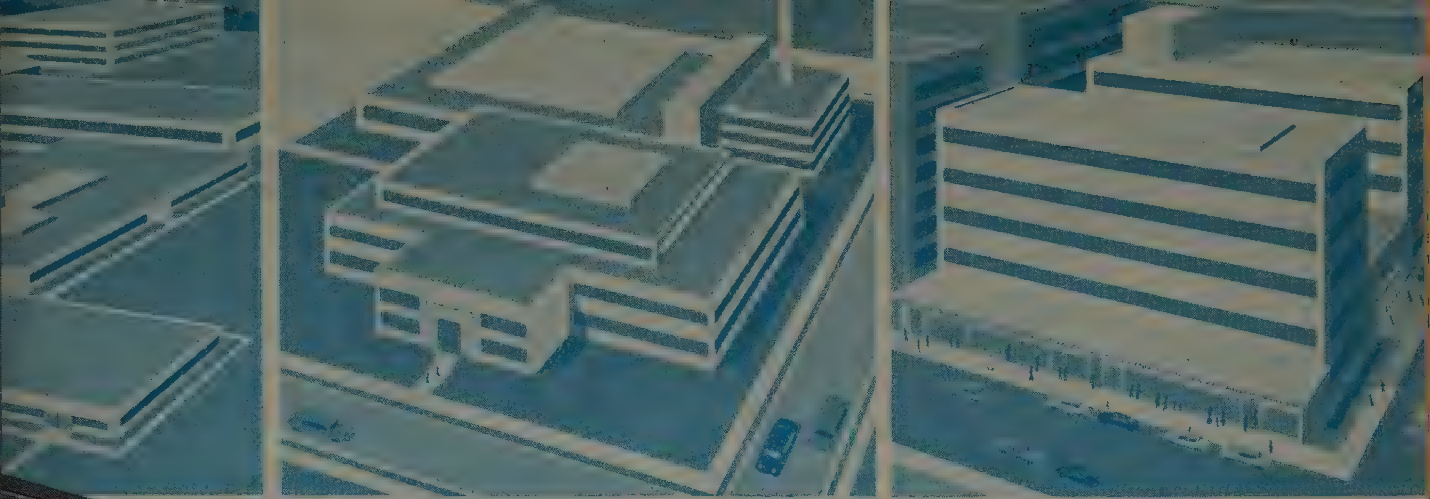

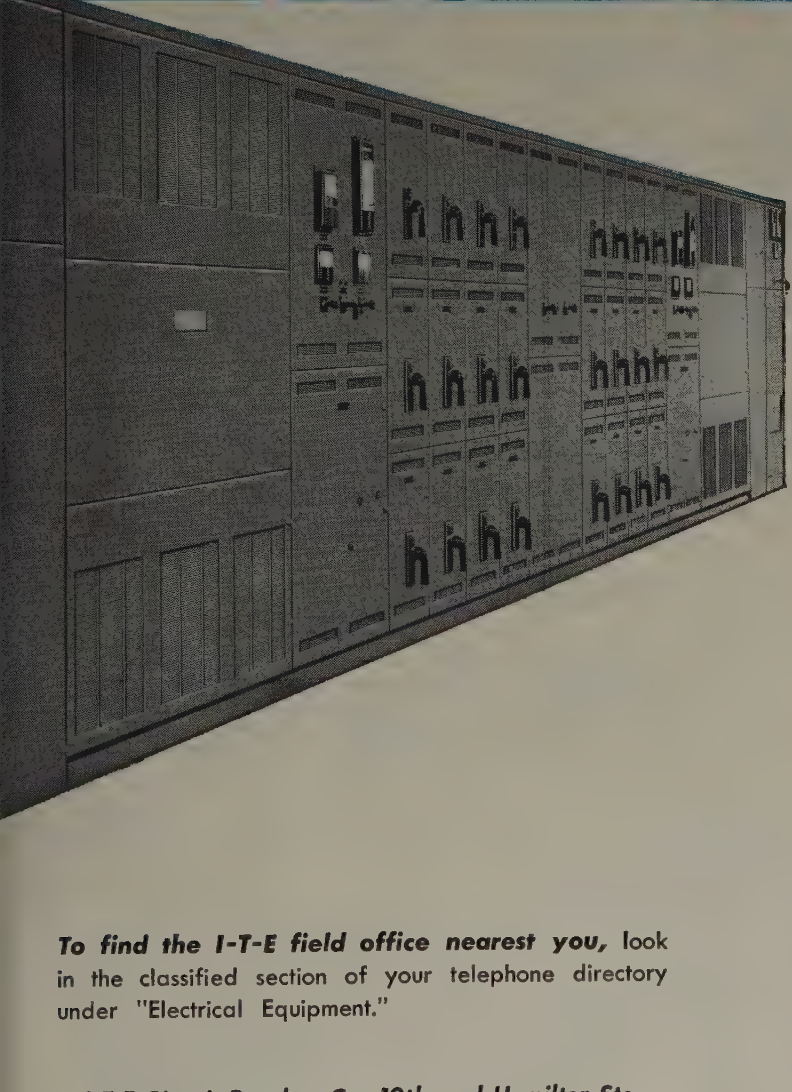

I-T-E offers a complete line of quality unit substation equipment

Through the years, I-T-E has led in the development and manufacture of quality circuit breakers and switchgear. Similarly, since the inception of the Unit Substation, and its use in modern distribution systems, I-T-E has continued to hold this same envied position. Today, I-T-E supplies a full line of quality Unit Substations, in types and sizes to fit every application.

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Prompt notification of a change of address accomplishes three things simultaneously: change of address in the AIEE national records; change of mailing address for ELECTRICAL ENGINEERING; and notice to the local section to change the section mailing list. Therefore, if you have an address change, fill out the form below and mail it promptly to: AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

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Street Address ....

City .... (Zone No.) .... State ....

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Mailing Address ....

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12-53

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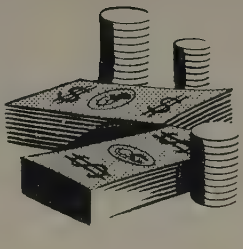

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In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of these advertisements, to pay placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, non-profit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns.

Apply by letter addressed to the key number and mail to New York Office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription rate of $3.50 per quarter or $12 per annum, payable in advance.

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ELEC ENGR, Purdue 1949; good exper in substations and in road lighting. Desires to work for an American or Canadian firm operating outside the U. S., being an alien. Present location, Egypt. E-729.

ELEC ENGR, B.S.E.E.; 37, family; 10 yrs constr, opern rural pwr systems; 4 yrs Army Radar, 1 yr pwr procurement. Desires responsible pos elec util, consulting engr or manufacturing. E-730.

Positions Available

ELECTRICAL STANDARDS LABORATORY MANAGER, 30–55, M.S. or Ph.D., preferably in physics, with thesis on instrumentation problems; minimum of 5 years' in industry, university or government laboratory in actual work of repair and calibration of high-grade indicating and recording electrical, electronic and mechanical instruments. Will take complete technical responsibility for the accuracy of the electrical measurements and develop laboratory into one of maximum utility and overall economy. Salary, $6,000–$8,500 a year. Location, Washington State. Y-9041.

ASSISTANT VICE PRESIDENT, Operations, 32–38, thoroughly familiar with the public utility field covering electricity and/or telephone, and gas and/or water, including operations, engineering and construction pertaining to such work. Must be able to analyze present rates, supervise the making of studies for new rates. Must be good administrator. Salary, $8,500–$10,000 a year. Location, Connecticut. Y-9060.

ELECTRICAL ENGINEER with at least 5 years' specification, application and promotional experience in electrical field, to organize and operate program for industrial and commercial relighting, make surveys, analyze lighting plans and prepare reports. Some traveling. Salary, $9,000 a year. Location, New York, N. Y. Y-9080.

CONSULTING ENGINEER, retired electrical engineer, part-time, for consulting work in the field of cable supporting racks and other methods of supporting interlocked armored cable used for installations in power plants and industrial buildings. Location, Pennsylvania. Y-9167.

CHIEF ASSISTANT ENGINEER, electrical engineering degree, with minimum of 5 years' experience in design and manufacture of fractional hp motors. Salary, $6,000–$7,000 a year to start. Location, Colorado. Y-9217.

DISTRICT ENGINEER, 30–40, with transmission and distribution engineering experience, for a public utility. Work will involve the changing of the present distribution system as well as sub-station and transmission requirements in addition to the day-to-day maintenance and construction requirements. Salary, $5,700–$6,000 a year. Location, Iowa. Y-9221.

MANUFACTURING MANAGER, 40–55, electrical graduate, to take complete charge of manufacturing plant of 500–600 people engaged in manufacture of electric switchgear and metal stampings. Must be definitely cost conscious, and any experience in mass production, such as the automobile industry, desirable. Salary, $12,000–$15,000 a year. Location, New York Metropolitan Area. Y-9263.

DEVELOPMENT ENGINEER, 25–50, B.S. or M.S. in electrical engineering, majored in electronics and some work in vacuum tubes application. Minimum of 2 years' experience. Will design and develop miniature and sub-miniature tubes. Design of tube components, develop processes and specifications. Advise in design of tools, jigs and fixtures and in test equipment and procedures. Salary, $4,200–$7,800 a year. Location, New York State. Y-9270.

DEAN OF ENGINEERING COLLEGE giving courses in electrical, mechanical, civil and chemical engineering. Should have some interest in research. Salary, $10,000–$12,000 a year. Location, Ohio. Y-9281.

ENGINEERS. (a) Development Engineer, electrical, 22–40, B.E.E. or B.S. in physics, majored in communication engineering, audio and acoustics. Will do development work on phonograph pickups and associated test equipment. Should have mechanical aptitude for work on miniature electro-mechanical assemblies. Salary, $4,056–$5,964 a year. (b) Electrical Engineer, degree, majored in electronics and vacuum tubes, for design, production, process and equipment engineering for cathode ray gun mounts. Experience in electron tube manufacturing desirable. Should have 10 years' experience in this field. Salary, $4,200–$7,800 a year. Location, New York State. Y-9294.

PERSONNEL-INDUSTRIAL RELATIONS-EMPLOYEE TRAINING. Public utility companies located in Latin America require men for positions of industrial relations engineers and supervisor of employee training and personnel departments. Applicants should have at least 5 years' experience in their particular specialty and general acquaintance with publc utility operations. Knowledge of Spanish or Portuguese desirable, but not required initially. Salary commensurate with position, experience and living costs. F-9301.

ELECTRIC UTILITY ENGINEER, under 45, with utility experience in hydraulics and electrical fields for permanent service abroad in the management and coordination of planning, engineering design and construction of production facilities. Salary open. Location, Foreign. F-9302.

ELECTRICAL ENGINEER OR PHYSICIST with B.S. in electrical engineering or physics with a major in electronics preferred. Should have 3 to 5 years' experience in electronics after graduation in industry or the service. Work will consist of design, experimental development and setting up specifications for electronic application on machinery and equipment. Will also include technical advice on the maintenance of all-present electronic equipment through the plants. Salary, $3,900–$4,680 a year. Location, Connecticut. Y-9303.

INSTRUCTOR OR ASSISTANT PROFESSOR, young, for department of electrical engineering, to teach some courses in mathematics, electronics, including networks, fields, ultra-high frequency. Opportunity to do outside work or participate in sponsored research. Location, East. Y-9324.

CONSULTING ELECTRICAL ENGINEERS, with 20 to 25 years' experience; one in operations, and the other in straight engineering of public electrical utility. Foreign assignment; 18 months. Salary open. Y-9327.

RESEARCH ELECTRONIC ENGINEERS. (a) Senior with at least 8 years' experience in UHF and VHF fields. Salary, $8,000–$10,000 a year. (b) Development Engineer for design and development of micro-wave equipment. Salary, $5,500–$6,500 a year. (c) Development Engineer with at least 2 years' experience on magnetic amplifiers. Salary, $4,800–$6,000 a year. (d) Junior Electronic Engineer, electrical graduate, for test and development. Salary, $4,200–$4,800 a year. Must be U. S. citizens. Location, Brooklyn, N. Y. Y-9328.

ASSISTANT RATE ENGINEER for permanent position with responsible public utility service organization located in New York. Good opportunity for qualified man having 5 years' experience with sound knowledge of public utility economics and operations and experience in field surveys, analysis, design and application of electric rates. Preferred age, 27–35. Company supervises public utilities in 11 Latin American countries. Applicant must be willing to undertake some travel in Latin America. Knowledge of Spanish or Portuguese helpful; can be acquired after employment. Y-9329.

DESIGNER, Motors, for a manufacturer. Age to 50, with at least 5 years' experience in designing motors and speed reducers. Duties will include designing and detailing, and manufacturing fractional hp motors. Salary, to $10,000 a year. Employer will negotiate fee. Location, Illinois. C-1353.

ASSISTANT CHIEF ENGINEER; must have equivalent of electrical engineering degree. Should have a minimum of 5 years' experience in design and manufacturing of fractional hp motors. Salary, $6,000–$7,000 a year. Company will pay expenses for interview for desirable applicants. Location, Colorado. C-1354.

PROJECT PRODUCTION ENGINEER, Apparatus Engineering Department; to 50, with at least 5 years' experience in practical apparatus production work. Familiar with precision machine tools, foundry and die-casting, plastic molding and assembly operations. Duties will include engineering design and models of electrical, optical and electro-mechanical devices for production. Will be buffer between engineering and production departments. Company manufactures instruments. Salary, $6,000 a year and up. Location, Colorado. C-1363.

SALES ENGINEER, electrical or mechanical, to 30, with at least 2 years' experience in sales or application of electrical equipment. Knowledge of mechanical power transmission and electronic circuitry. Will sell a line of electrical clutches and power transmission, variable drives and electronic speed controls. Training position to District Manager. Company manufacturers transmission equipment. Salary, $4,800–$6,000 a year, plus commission and expenses. Employer may negotiate fee. Headquarters, Wisconsin. C-1394.

PROFESSORS AND INSTRUCTORS, M.S. and Ph.D. required. Openings for mechanical, civil, chemical, petroleum and electrical engineers. Mechanical engineers should be specialized in heat power, refrigeration and air conditioning or machine design; civil should have structural design experience. Electrical should be qualified in power or electronics. Vacancies for September, 1954. Salary, to $5,900 for 9 months plus 25% of summer work. Location, South. C-1398.

UTILITIES ENGINEER, electrical, professional license by examination; to 45, with at least 5 years' experience in plant engineering, designing or laying out electrical systems, or operations. Knowledge of utilities in general. Will do consulting work in utilities to improve operations and reduce costs. Salary, $7,800 a year. Some travel, home weekends. Car helpful. Employer will pay fee. Headquarters, Chicago, Illinois. C-1402.

ENGINEERING SUPERVISOR, engineering degree, 30–50, with at least 5 years' experience in electromagnetic controls in high-volume production and preferably 2 years' in supervisory capacity. Knowledge of manufacturing operations and finishes. Will supervise product performance affected by design changes at request of manufacturing department. Company manufactures gas appliances. Salary, $7,200–$9,000 a year. Employer will pay fee. Location, Wisconsin. C-1409.

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For help and situations wanted, $1.50 per line. Sale and purchase of used machinery, etc., $2.00 per line, minimum 5 lines, maximum 30 lines, not available to dealers. Address orders to: Classified Section, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 36, N. Y.

When answering an advertisement, send all replies to box number specified, c/o ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 36, N. Y., unless other address is given.

Positions Open

SALES ENGINEER, age 25–35, some technical background desirable, to call on utility industry from Chicago office of long established cable company. Permanent position, salary and expenses. State age, education, experience, references, salary. Box 466.

SALES ENGINEERS—Openings available with large industrial instrument manufacturer for field Sales Engineers in New York, Chicago, Pittsburgh, Houston, and St. Louis areas. Graduates of recognized engineering colleges with training in electronics preferred. Mechanical and Chemical Engineers will also be considered. Excellent opportunity for young engineers with sales aptitude who wish to enter the fast-growing industrial instrument field with a long established and rapidly growing manufacturer of industrial instruments. Write Box 475.

ENGINEERS for professorships all engineering fields, Master's and Doctor's qualify unusually fine positions, $4500–$7000 nine months. Instructors, bachelors. Give phone, photo, qualifications. Cline Teachers' Agency, East Lansing, Michigan.

PERSONNEL-INDUSTRIAL RELATIONS-EMPLOYE TRAINING—Public utility companies located Latin America require men for positions of industrial relations engineers, and supervisors of employe training and personnel departments. Applicants should have at least 5 years' experience in their particular specialty and general acquaintance with public utility operations. Knowledge of Spanish or Portuguese desirable but not required initially. Positions offer promising fields for applicants with individual initiative, having good background of practical experience in their particular field. Salary commensurate with position, experience and living costs. Reply stating age, education, experience and personal particulars. Box 479.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY'S DIGITAL COMPUTER LABORATORY of the Department of Electrical Engineering needs some highly qualified engineers and scientists in developing high-speed electronic digital equipment (logical design, vacuum-tube and magnetic-core circuitry, and mechanical design and packaging to make equipment suitable for production). There is also work on use of high-speed digital computers to control large physical systems. This involves study of control requirements of the whole system, reduction of them to a simple pattern of control instructions, and translation of the pattern into computer code. Position requires appreciation for physical systems, ingenuity, and imagination. Training in computer principles provided as necessary. Persons from other fields wishing experience in digital computers for engineering and military uses are encouraged to apply and may come on leave from their permanent organizations. Positions carry opportunity for advancement. Salary appropriate to candidate's experience and training. Address: Digital Computer Laboratory, MIT, 211 Massachusetts Avenue, Cambridge 39, Massachusetts.

Positions Wanted

SALES ENGINEER, 50, married, SB in EE (MIT) background includes G.E. test, engineering and sales experience, have knowledge of inspection and quality control procedure. Now employed in power plant insurance, desire more technical work. Adaptable and in good health. Prefer locate Pittsburgh district or East. Box 459.

ELECTRICAL ENGINEER, 18 years' experience in light, power and signal design, layout, construction and maintenance in chemical, food and other industrial plants in leading positions. Knowledge of Spanish, French and German. Box 480.

ELECTRICAL ENGINEER, BSEE, MSEE, Navy electronic technician, 1 year management training, 1 year college instructor of electronics, 3 years field service airborne electronics equipment. Desires sales or service position. Box 481.

ELECTRICAL ENGINEER, BSEE, Reg. PE; AIEE, age 47, family, 22 years broad experience in engineering distribution and industrial departments of Electric Public Utility. Last 7 years responsible position in U.G. Network Department in large city with several large networks. Box 482.

PHYSICIST-ENGINEER, British, age 44, married, 20 years academic and industrial experience in organizing and directing research and development laboratories: radiac and nucleonic instrumentation, information and data processing devices (digital and analogue), radar, high-vacuum and solid state electronics. Desires responsible position and commensurate salary with progressive firm or university, location immaterial but genial climate essential. Write Box 483.

ASSOCIATE PROFESSOR at leading eastern college seeks improved academic research position on the west coast or far west. 17 years of professional experience in radio engineering, many publications, specialized in wave theory and antennas. European background, over 5 years in the U.S. Present compensation $9,000 for 11 months. Write Box 484.

ELECTRICAL ENGINEER, power, 31, BS AND MS in EE and Business, wants position. 2 years' experience testing power plant equipment, 3 years University Instructor. Prefers sales for power plant equipment or field representative. Speaks 5 languages fluently. High administrative abilities, effective in meeting people. Box 485.

ELECTRONIC AND SERVO ENGINEER, MSEE 53, age 29, family. 5 years R and D work, 3 in pulse circuitry and 2 in servo systems. Desire similar work. Interested in South America. Box 486.

ELECTRICAL ENGINEER, BSEE, age 41, family. 15 years' experience in planning, design, construction, and supervision of power transmission and distribution systems and related building construction. Desire responsible administrative, managerial, or supervisory position with progressive industrial firm, electrical manufacturer or distributor, utility or other business where engineering education and experience can be utilized. Location: Pacific Northwest. Box 487.

ELECTRICAL ENGINEER, BS(EE) '51, married, 28 years old, 8 months telephone power equipment engineer, 2 years design and layout of electrical equipment for modern hot and cold strip mill. Desire engineering position that has opportunity for advancement based on ability and initiative. Resume on request. Box 488.

MECHANICAL AND ELECTRICAL ENGINEER, Harvard Business School graduate, registered, Member ASME, AIEE, AIME, 48, family, domestic and foreign experience in fine mechanics, instruments and controls (including electronics) and process industries, ability in development, manufacture, application and administration, seeks consulting connections or full time with stable company. Philadelphia or East preferred. Write Box 489.

TRANSFORMER ENGINEER, audio, power and pulse, BSEE, 34, family, desires consulting or supervisory position with progressive firm. 8 years' experience with large research and development organization, presently employed in responsible staff position with small firm and desire to move due to new management policy. Box 490.

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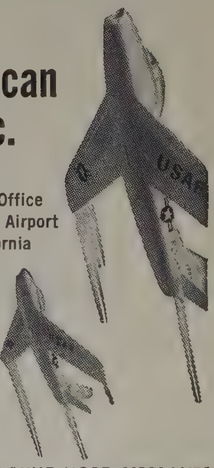

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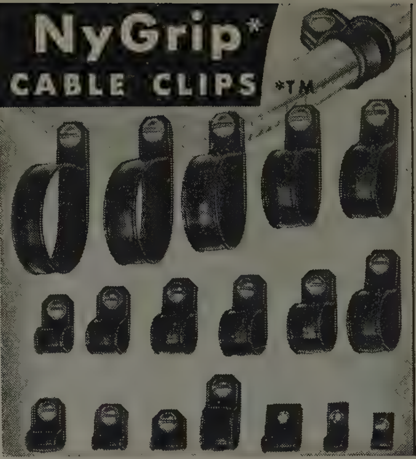

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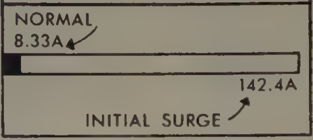

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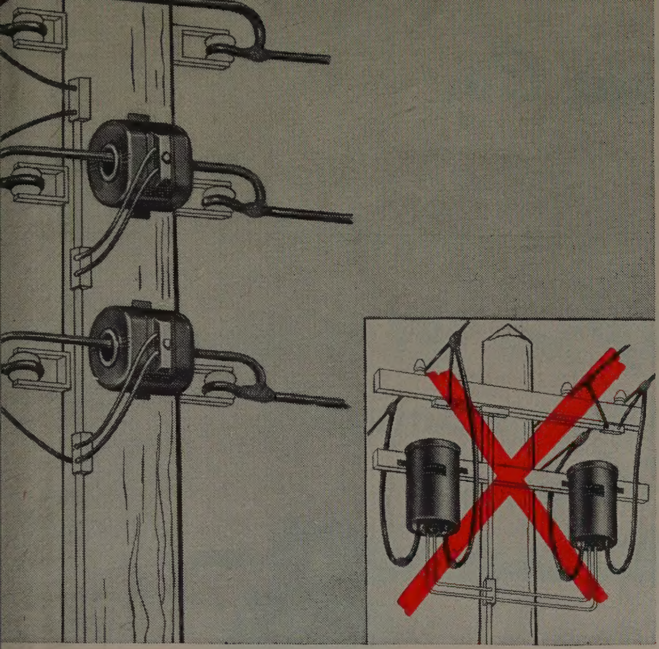

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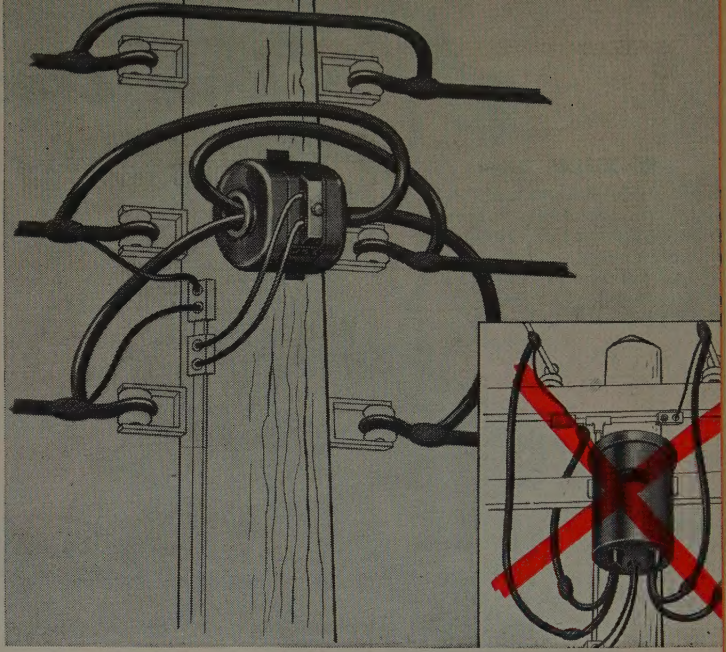

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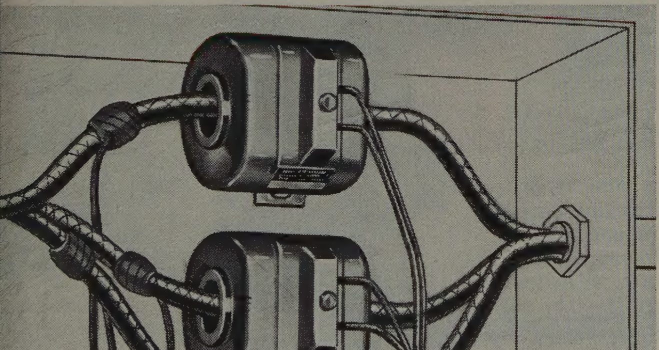

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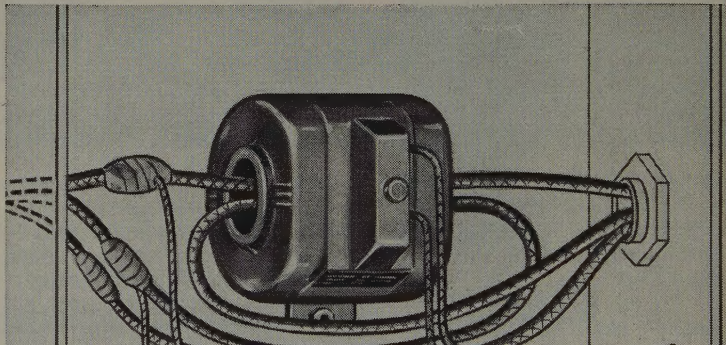

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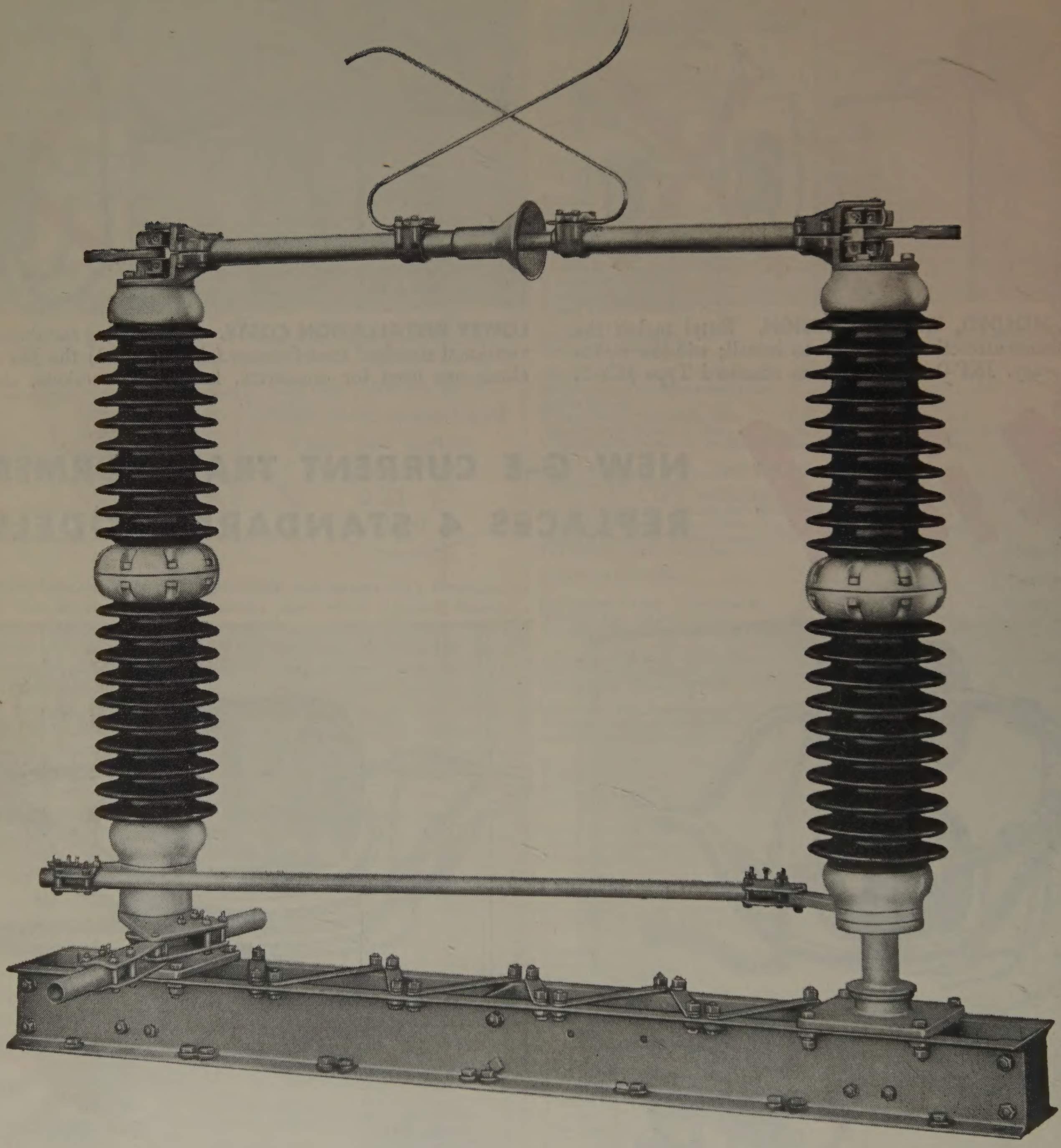

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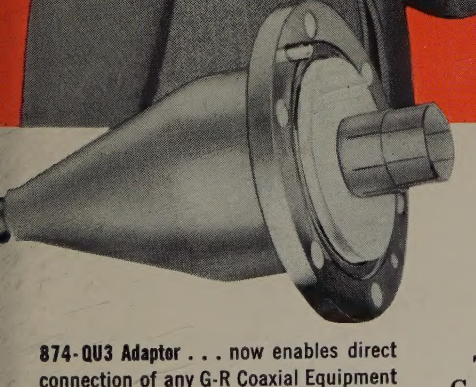

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